MP MASTER
MA24139

RACAL

TECHNICAL INFORMATION

AUTOMATIC FREQUENCY CONVERTER
TYPE SA. 541

Operating and Maintenance Manual
(Provisional)

Technical Handbooks Department

RACAL INSTRUMENTS LIMITED
Dukes Ride,
Crowthorne, Berkshire,
England.

Tel. Crowthorne 2272

Ref. No. 263
Issue 1-1-67-200

Racal Copyright

Printed in England

CONTENTS

PRELIMINARY PAGES
- Title Page
- Warning Card
- Note to Users
- Handbook Change Information

FRONTISPIECE
TECHNICAL SPECIFICATION

	Section
GENERAL DESCRIPTION	1
OPERATING INSTRUCTIONS	2
MAINTENANCE	3*
TECHNICAL DESCRIPTION (Including assembly parts lists, components lists, component layouts and circuit diagrams)	4 - 7
ADDITIONAL ASSEMBLY INFORMATION	8

* To be issued later

DANGER LETHAL VOLTAGES

Although every reasonable precaution has been observed in design to safeguard operating personnel this warning is ...

VITAL !

ADJUSTMENTS

EXERCISE GREAT CARE

DO NOT ADJUST ALONE

If possible, when making adjustments, ensure the presence of another person capable of rendering aid.

SERVICING

SWITCH OFF

DO NOT TAMPER WITH INTERLOCKS

Only authorised personnel should be allowed to remove or neutralise the effect of interlocks. Do not rely on interlock switches for protection.

DO NOT SERVICE ALONE

If possible, when servicing, ensure the presence of another person capable of rendering aid.

SEE OVER FOR RESUSCITATION INSTRUCTIONS

FIRST AID in case of Electric Shock

1. Lay victim on his back.
2. Clear victim's mouth and throat.
3. Tilt victim's head back as far as possible and raise his head.
4. Pinch victim's nostrils.
5. Take a deep breath.
6. Cover the victim's mouth with yours and blow, watching his chest rise. Note: Blow forcefully into adults, but gently into children.
7. Move your face away to allow victim to breathe out, watching his chest fall.
8. Repeat first five to ten breaths at a rapid rate; thereafter, take one breath every three to five seconds.
9. Keep victim's head back as far as possible all the time.

Have someone else send for a Doctor

Keep patient warm and loosen his clothing

DO NOT Give liquids until patient is conscious

NOTES TO USERS

DISPOSITION OF INFORMATION

1. The information contained in this handbook is arranged in accordance with a new four-point standard breakdown, as described in the following paragraphs.

System-type Information

2. Definition System-type information may be defined as most of that material generally found in the handbook under such headings as 'General Description', 'Operating Instructions", 'Setting Up', 'Dismantling and Reassembly', 'Fault-finding' etc.

3. Breakdown System-type information is broken down into as many sections as are required, the number used being governed entirely by the complexity of the instrument involved.

4. Pagination This is of the numeric type 1-1, 1-2....2-1,2-2.. ..3-1,3-2...etc., where the two digits indicate section and page in that order.

5. Tables These are allocated reference (table) numbers of the type used in pagination, e.g. Tables 1-1, 1-2.....Tables 2-1, 2-2.... etc.

6. Illustrations These are allocated reference (figure) numbers on the same basis as tables.

Main Assemblies Information

7. Definition Main assemblies information may be defined as most of that material previously collected together in the handbook under such headings as 'Circuit Description', 'Components List', 'Diagrams' etc. In the four-point standard breakdown, main assemblies information always follows system-type information.

8. Breakdown Main assemblies information is broken down into self-contained sections, the basis of compilation being one section for each different main assembly.

9. Pagination This is similar in principle to that used for system-type information except that it is based on two-letter section codes instead of section numbers, e.g. AA-1, AA-2.....BK-1, BK-2..... etc.

10. Tables These are allocated reference (table) numbers of the type used in pagination, e.g. Tables AA-1, AA-2..... Tables BK-1, BK-2.....etc.

11. Illustrations These are allocated reference (figure) numbers on the same basis as tables, e.g. Figs. AA-1, AA-2..... Figs. BK-1, BK-2.....etc.

12. Section Codes These two-letter codes are derived from the last four digits of the main assembly part number; the following examples illustrate the connection.

AA = 0000, AB = 0001.....AY = 0022, AZ = 0023

BA = 0024, BB = 0025..... ..BY = 0046, BZ = 0047

CA = 0048, CB = 0049..... .....CY = 0070, CZ = 0071

Additional Assemblies Information

13. Definition Additional assemblies information is all that assembly material which is unsuitable for inclusion with that in either of the two categories already defined, e.g. minor electrical and p.c.b. assemblies, chassis assembly information and overall instrument assembly information. In the new standard breakdown, additional assemblies information always follows the main assemblies information sections.

14. Breakdown Additional assemblies information consists of a single part or section and will usually take the form of parts lists, components lists, component layout diagrams, detailed interconnection diagrams etc.

15. Pagination This is of the numeric type used for paginating system information.

16. Tables These are allocated reference (table) numbers of the type used in pagination.

17. Illustrations These are allocated reference (figure) numbers on the same basis as tables.

Uncategorized Information

18. Definition Uncategorized information may be defined as all that material generally included in handbooks in the form of appendices. In the standard breakdown, uncategorized information always follows that on additional assemblies.

19. Breakdown Uncategorized information breaks down into self-contained appendices, the number used being entirely dependent on the nature and extent of the information involved.

20. Pagination This is basically the same as that used for paginating system information except that the digits are prefixed by the letter A (for appendix) e.g. A1-1, A1-2.....A2-1, A2-2.....A3-1, A3-2.....etc.

21. Tables These are allocated reference (table) numbers of the type used in pagination, e.g. Tables A1-1, A1-2..... ....Tables A2-1, A2-2..... . etc.

22. Illustrations These are allocated reference (figure) numbers on the same basis as tables, e.g. Figs. A1-1, A1-2.....Figs. A2-1, A2-2..... . etc.

TERMINOLOGY - UNIT OF FREQUENCY

23. The basic unit of frequency used in this handbook is the Hertz (cycles per second), which is in accordance with the recent Oslo conference of the C.C.I.R. Instead of the abbreviations c/s, kc/s and Mc/s, the handbook now uses Hz, kHz and MHz. For consistency this ruling has also been applied to instruments manufactured prior to the changeover.

CIRCUIT REFERENCES - TRANSISTORS

24. The transistor circuit reference prefix used in this handbook is the single letter Q, which is in accordance with the I.E.E.E. standard. Resistors, capacitors etc., are all prefixed in accordance with B.S.S.

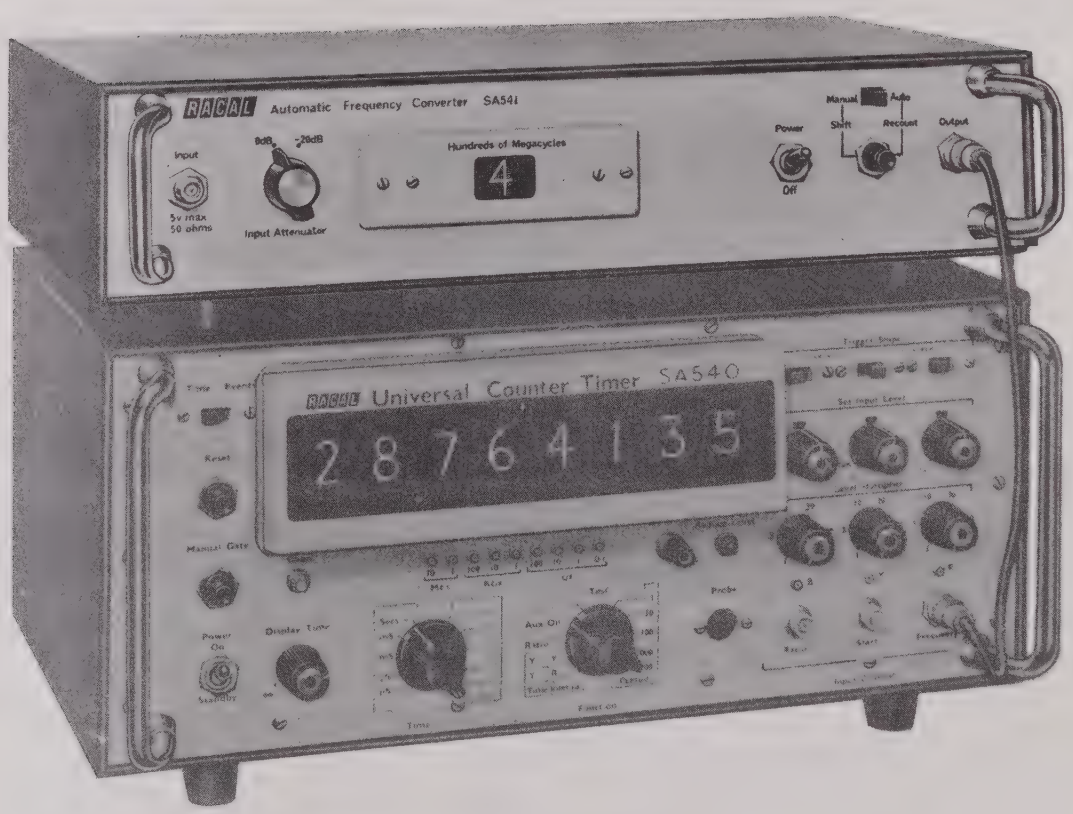
HANDBOOK CHANGE INFORMATION

At RACAL, we continually strive to keep up with the latest electronic developments by adding circuit and component improvements to our equipments.

Sometimes, due to printing and despatch requirements, we are unable to incorporate these changes immediately into printed handbooks. Hence, your handbook may contain new change information on following pages.

The user is recommended to hand-amend this handbook, as soon as possible, in accordance with the corrections, if any, which follow this sheet.

NOTES



SA.541 AUTOMATIC FREQUENCY CONVERTER WITH
SA.540 UNIVERSAL COUNTER-TIMER

TECHNICAL SPECIFICATION

AUTOMATIC FREQUENCY MEASUREMENT

Frequency Range	3MHz to 500MHz
Input Impedance	50 ohms
Sensitivity	Less than 100mV r.m.s.
Input Attenuator	X10
Maximum Input Level	5V r.m.s.
Output Frequency Range	150kHz to 10.5MHz
Output Level	Greater than 100mV r.m.s. into 50 ohms

MANUAL FREQUENCY MEASUREMENT

Frequency Range	3MHz to 500MHz
Input Impedance	50 ohms
Sensitivity	Less than 50mV r.m.s.
Input Attenuator	X10
Maximum Input Level	5V r.m.s.
Output Frequency Range	150kHz to 10.5MHz
Output Level	Greater than 100mV r.m.s. into 50 ohms

GENERAL

Accuracy	Retains accuracy of external reference
Reference Frequency	10MHz
Reference Level	Greater than 100mV r.m.s. into 50 ohms *
Power Supplies	115V, 200V, 220V, 240V (± 10%) 48Hz to 65Hz
Power Consumption	25 watts
Auxiliary Output (Optional)	B.C.D. output of hundreds-of-megahertz digit weighted 1248 at nominal logic levels of 0V & +6V
Dimensions	$3\frac{1}{2}$ in. (height) x $16\frac{3}{4}$ in. (width) x 12 in. (depth) (9 cm.) (42.5 cm.) (30.5 cm.)
Weight	10 lb. (4.5 kg.)

* When the SA.541 is used with a 10Mhz counter other than the SA.540, the reference input impedance is approximately 600 ohms.

SECTION 1

GENERAL DESCRIPTION

CONTENTS

	Page
FUNCTION	1-1
MAIN ELECTRICAL ASSEMBLIES	1-1
POWER SUPPLIES	1-2
BRIEF TECHNICAL DESCRIPTION	1-2
PREPARATION FOR USE	1-3

Illustrations

	Fig.
Simplified Functional Diagram	1-1

FUNCTION

1. The SA.541 Automatic Frequency Converter is designed for use with the Racal Universal Counter-Timer SA.540, or any other suitable 10MHz counter, to provide direct, automatic and continuous frequency measurement throughout the range 2MHz to 500MHz. The unit is available (a) combined with an SA.540 to form a self-contained 500MHz digital frequency meter (see SA.560 handbook) or (b) as a free-standing adaptor (see frontispiece).

MAIN ELECTRICAL ASSEMBLIES

2. For descriptive purposes, the unit is broken down into its four main electrical assemblies:-

		SECTION No.	SECTION Code Letters
(a)	500MHz A.F.C. Assembly 11-0000	4	AA
(b)	Auxiliary Power Supply Assembly 11-0031	5	BH
(c)	Power Supply Assembly 11-0033	6	BK
(d)	Bi-Quinary Scaler P.C.B. Assembly 19-0049	7	CB

3. Additional assembly information (parts lists, components lists, component layouts and circuit diagrams) is given in Section 8.

POWER SUPPLIES

4. The unit is designed to operate from 115V/230V (±10%), 48Hz to 450Hz single-phase a.c. mains (mains transformer tappings at 110V, 120V, 200V, 220V and 240V).

BRIEF TECHNICAL DESCRIPTION

General

5. The simplified functional diagram of the unit (Fig. 1-1) shows that it consists of (1) a 2MHz to 500MHz heterodyne frequency converter followed by (2) a 100kHz to 100MHz decade frequency divider. On its own the converter is capable of extending to 500MHz the frequency measurement range of the Racal 100MHz Universal Counter-Timer Type SA.550. To similarly extend the frequency measurement range of the Racal Universal Counter-Timer Type SA.540 , or of any other suitable 10MHz counter, the converter output has to be scaled down in frequency by a factor of ten.

Principle of Operation of the Converter

6. The 10MHz reference frequency input to the converter is multiplied in frequency to provide heterodyne harmonics at 100MHz, 200MHz, 300MHz and 400MHz. One of the four harmonics is selected by the converter automatic frequency control system for mixing in a balanced mixer with the input signal frequency (f_s). The mixer product required is the difference or lower sideband frequency, that is to say the signal frequency minus the selected heterodyne frequency (f_o). This difference is then passed to a wideband amplifier and a low-pass filter which severely attenuate frequencies outside the passband of the decade frequency divider input circuit.

7. For example, assume that the frequency of the input signal is 222MHz. The requirement, in order to measure this frequency correctly, is for the automatic frequency control system to select the particular 100MHz harmonic which will beat with the signal frequency to produce a difference frequency of 22MHz. Clearly, this condition is fulfilled when the automatic frequency control system selects the harmonic at 200MHz, i.e. the one immediately <u>below</u> the signal frequency.

8. Assume now that instead of selecting the harmonic immediately below the signal frequency, the automatic frequency control system selects the one immediately <u>above</u> it. The difference frequency fed to the wideband amplifier is now the heterodyne frequency at 300MHz minus the signal frequency at 222MHz, i.e. 78MHz. Since this is also within the passband of the decade frequency divider input circuit, it could be indicated upon the counter, giving a displayed measured frequency of 378MHz instead of the correct frequency indication of 222MHz.

9. To avoid having to distinguish between the above two conditions, the automatic frequency control system selects the heterodyne frequencies in the order 100MHz, 200MHz, 300MHz and finally 400MHz. If now the converter locks on

to the first signal capable of giving a display on the counter, there can be no possibility of error since the resulting lower sideband response must be caused by the heterodyne frequency immediately below the signal frequency. In addition to removing any ambiguity that could exist because of wrong sideband selection, this method of scanning the heterodyne frequency generation circuits provides a system of measurement which is fully automatic, i.e. requiring neither tuning nor interpolation.

Search (A) Scans and Automatic Level Check

10. In the absence of an input signal, the converter successively tries heterodyne frequencies of 0, 100, 200, 300 and 400MHz in an attempt to find a response. During this time the legend CHECK LEVEL is displayed on the front panel of the unit. If, when the input signal is applied to the unit, its frequency or its amplitude is not within the limits specified (see Technical Specification) the legend will continue to be displayed, indicating that the signal cannot be measured.

Detection (B) Scan and Lock-on

11. When the input signal is applied to the unit, then providing its frequency and amplitude are such that it can be measured, it will beat with one or other of the heterodyne frequencies on the A scan to produce a difference frequency acceptable to the decade frequency divider input circuit. This condition is immediately detected by the automatic frequency control system which then (a) increases the sensitivity (to provide additional operating margins) and (b) sets the heterodyne frequency to 0MHz. From 0MHz, the heterodyne frequency is then advanced in 100MHz steps until a response is obtained. The heterodyne frequency remains fixed at whichever setting the response occurs until either (a) the input signal is removed, (b) its frequency moves out of band, or (c) its amplitude falls below that necessary to operate the unit.

12. The CHECK LEVEL legend displayed during the A scan of the heterodyne frequencies is replaced at the end of the B scan by a numerical display indicating the hundreds-of-megahertz to be added to the reading displayed on the counter.

PREPARATION FOR USE

13. Before connecting the instrument to the mains, check the following:

(1) That the POWER switch is set to OFF.

(2) That the LINE and NEUTRAL mains fuses are rated in accordance with the available mains voltage, viz:-

200V, 220V, 240V	1 amp fuse
110V, 120V	2 amp fuse

(3) That the mains voltage selector is set to suit the available mains voltage.

14. Having ensured that the correct fuses are fitted and that the voltage selector is correctly positioned, the unit may now be connected to the mains and switched ON. Before any measurements are carried out however, users are recommended to check the operation of the counter using its in-built TEST facility.

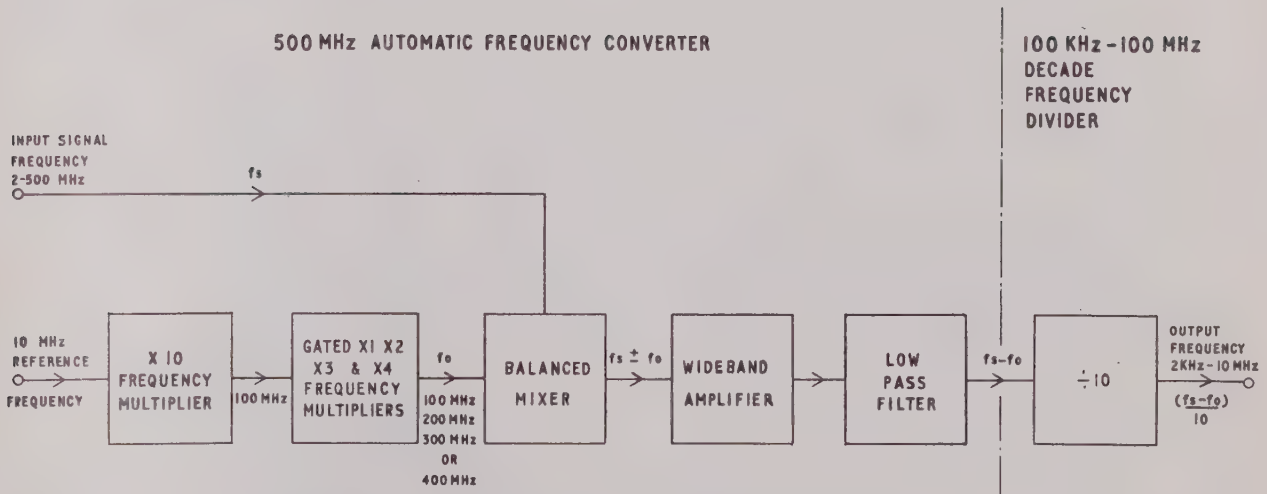


Fig.1-1 Simplified functional diagram: SA.541

SECTION 2

OPERATING INSTRUCTIONS

CONTENTS

	Page
CONTROLS AND FACILITIES	2-1
PRELIMINARY CHECKS	2-2
CHECKING THE COUNTER	2-2
OPERATING PROCEDURES	2-2

CONTROLS AND FACILITIES

Front Panel

1. (a) INPUT socket - accepts signal frequency to be measured.

   (b) INPUT ATTENUATOR - selects either X1 (0 dB) or $X10^{-1}$ (20 dB) sensitivity range as required.

   (c) Indicator panel In the event of the signal frequency being below the rated sensitivity of the converter (100 mV) the panel displays the legend CHECK LEVEL - otherwise it indicates the 'hundreds of megahertz (megacycles)' content (0, 1, 2, 3 or 4) of the signal frequency.

   (d) POWER switch - switches the a.c. mains (power) supply to the converter power unit.

   (e) MANUAL/AUTO switch - selects required mode of operation.

   (f) SHIFT/RECOUNT push-button In MANUAL operation the push-button advances the local oscillator frequency in 100 MHz steps; in AUTO it has the effect of resetting the automatic control system to zero.

   (g) OUTPUT socket - carries the appropriate lower sideband response scaled down in frequency to the range (approximate) 200 kHz - 11 MHz for measurement in the counter.

Rear Panel

2. (a) 10 MHz REF IN socket - accepts either (1) the 10 MHz reference frequency output of the counter or (2) that of any other suitable 10 MHz reference frequency source.

   (b) MAINS socket - accepts the a.c. mains (power) supply for the converter power unit.

PRELIMINARY CHECKS

3. Before operating the converter for the first time, the following points should be verified:

(1) That the POWER switch is OFF.

(2) That the voltage selector in the converter power unit is set in accordance with the available mains voltage.

(3) That the LINE and NEUTRAL mains supply fuses are rated in accordance with the available mains supply voltage.

Mains Voltage	Main Fuse Ratings
200V, 220V, 240V	1 amp
110V, 120V	2 amp

NOTE: The voltage selector and fuse panel of the converter power unit is exposed to view by unscrewing and removing the four bolts securing the feet and the base cover to the main chassis.

4. The converter can now be connected to the a.c. mains (power) supply and switched ON.

CHECKING THE COUNTER

5. Before carrying out any measurements, the user is recommended to check the operation of the counter, using its in-built TEST facility. Details of the procedure for checking the counter are given in the counter handbook.

OPERATING PROCEDURES

6. Though designed to be fully automatic in operation, the converter is also capable of being operated manually. This facility is of use (1) in test and maintenance generally, where it is advantageous to be able to set the local oscillator to a particular frequency and hold it there and (2) where the higher sensitivity obtainable in this mode makes it preferable to automatic working.

7. In setting out the operating procedures it has been assumed (1) that the counter has been switched ON and allowed to warm-up in accordance with the recommendations in the counter handbook and (2) that connections have been made between the FREQUENCY OUTPUT and 10 MHz sockets of the two instruments as follows.

Counter		Converter
FREQUENCY	to	OUTPUT
STD 10 MHz OUT *	to	10 MHz REF IN

* This connection should be made only if it is intended to use the 10 MHz reference frequency output of the counter and not that of some other suitable 10 MHz reference source (see paragraph 2).

Automatic Frequency Measurement

8. On the counter:

(1) Set the FUNCTION switch to FREQ KC/S.

(2) Check that the TIME/EVENTS switch is set to TIME.

(3) Set the frequency channel SET INPUT LEVEL and LEVEL MULTIPLIER controls fully anti-clockwise.

On the converter:

(4) Check that the POWER/OFF switch is set to POWER.

(5) Set the AUTO/MAN switch to AUTO.

(6) Set the INPUT ATTENUATOR to 20 dB.

(7) Apply the signal frequency to be measured to the INPUT socket.

(8) Check the display. If either of the digits 0 to 4 lights up, complete the measurement in accordance with operations (11) to (14). If, on the other hand, the legend CHECK LEVEL is displayed, proceed as follows.

(9) Set the INPUT ATTENUATOR switch to 0 dB.

(10) Re-check the display. If the legend CHECK LEVEL continues to be displayed, the input signal level is probably less 100 mV (the sensitivity rating) and thus too low for the converter to operate.

(11) Press the SHIFT/RECOUNT button once; a reading should now be displayed on both instruments.

On the counter:

(12) Set the TIME/GATE switch as required.

(13) Set the DISPLAY TIME control as required.

On the two instruments:

(14) Read off the frequency of the input signal by adding the display on the converter (hundreds of megahertz) to the display on the counter (megahertz).

NOTE: To convert the counter display (which is in kilohertz (kilocycles)) to read directly in Megahertz, its reading must be divided by 100. This is equivalent to shifting the decimal point three places to the left to convert to megahertz, and one place to the right to compensate for the fact that in the converter the lower sideband response is scaled down by a factor of ten to make it acceptable to the counter.

Manual Frequency Measurement

9. The procedure here is the same as that for automatic measurement except that it is carried out with the AUTO/MAN switch at MAN; in this position of the mode selector switch the SHIFT/RECOUNT push-button switch is used to perform the local oscillator frequency selection previously carried out by the automatic control system.

10. To illustrate the use of the SHIFT/RECOUNT push-button in manual frequency measurement, assume that the frequency of the input signal is in the range 202 MHz to 302 MHz. Whatever the actual signal frequency in this range, it can be shown that there are always two possible lower sideband responses, viz: the correct one due to the local oscillator frequency immediately below the signal and (2) an ambiguous and incorrect response due to the local oscillator frequency setting immediately above the signal frequency. In the case of a signal in the range 202 MHz to 302 MHz, the correct lower sideband response is obtained with the local oscillator frequency set to 200 MHz. This is the condition when digit '2' is displayed on the converter indicator panel, hence in the example chosen the SHIFT/RECOUNT push-button is operated as necessary until this particular digit is displayed.

11. Selecting the correct lower sideband response is equally straight-forward for signal frequencies in either of the three ranges (1) 3 MHz to 102 MHz, (2) 302 MHz to 402 MHz and (3) 402 MHz to 502 MHz. Whereas in the case of signals in the range 202 MHz to 302 MHz the SHIFT/RECOUNT is operated as required to bring up the digit '2', so in these three ranges it is operated as necessary to display '0', '3' and '4' respectively.

12. Manual selection of the correct lower sideband response for signals in the range 102 MHz to 202 MHz involves a slightly different approach since in the converter this range is covered in two stages, namely 102 MHz to 160 MHz and 160 MHz to 202 MHz. The point to note when measuring a signal in either of these two frequency ranges is that the required 'hundreds of megahertz (megacycles)' display on the converter is the same in each case, i.e. digit '1'. To ensure selection of the correct range, the lowest range of all, viz: 3 MHz to 102 MHz, should be selected first (i.e. the SHIFT/RECOUNT button operated as required to bring up digit '0'). Having done this, the range 102 MHz to 160 MHz is selected by depressing the SHIFT/RECOUNT button once and range 160 MHz to 202 MHz by depressing it twice.

SECTION 3

MAINTENANCE

To be issued later

SECTIONS 4-7

TECHNICAL DESCRIPTION

CONTENTS

Section No.	Item	Code Letters
4	500MHz A.F.C. Assembly 11-0000	AA
5	Auxiliary Power Supply Assembly 11-0031	BH
6	Power Supply Assembly 11-0033	BK
7	Bi-Quinary Scaler P.C.B. Assembly 19-0049	CB

SECTION AA

TECHNICAL DESCRIPTION

500 MHz A.F.C. ASSEMBLY 11-0000

CONTENTS

	Page
INTRODUCTION	
Function	AA-4
Brief Electrical Specification	AA-4
GENERAL TECHNICAL DESCRIPTION	
Functional Breakdown	AA-4
Signal Circuits	AA-5
General Principles of Operation	AA-5
Suppression of Unwanted Responses	AA-6
Operation in the Range 2 MHz to 102 MHz	AA-8
Signal Gating	AA-9
Control Circuits	AA-9
General Operation	AA-9
Auxiliary Reset 'A' Action	AA-11
Auxiliary Reset 'B' Action	AA-12
Manual Operation	AA-13
DETAILED TECHNICAL (CIRCUIT) DESCRIPTION	
X10 Multiplier P.C.B. Assembly 19-0001 (AFC1)	AA-13
Harmonic Selector P.C.B. Assembly 19-0002 (AFC2)	AA-14
Balanced Mixer P.C.B. Assembly 19-0003 (AFC3)	AA-15
100 MHz Amplifier P.C.B. Assembly 19-0004 (AFC4)	AA-16
Filter, Gate and Detector P.C.B. Assembly 19-0005 (AFC5)	AA-16
Shift Register P.C.B. Assembly 19-0006 (AFC6)	AA-18
Control P.C.B. Assembly 19-0007 (AFC7)	AA-22

Tables

	Table
X10 MULTIPLIER P.C.B. ASSEMBLY 19-0001	
Parts List	AA-1
Components List	AA-2
HARMONIC SELECTOR P.C.B. ASSEMBLY 19-0002	
Parts List	AA-3
Components List	AA-4

BALANCED MIXER P.C.B. ASSEMBLY 19-0003

Parts List AA-5
Components List AA-6

100MHz AMPLIFIER P.C.B. ASSEMBLY 19-0004

Parts List AA-7
Components List AA-8

FILTER, GATE AND DETECTOR P.C.B. ASSEMBLY 19-0005

Parts List AA-9
Components List AA-10

SHIFT REGISTER P.C.B. ASSEMBLY 19-0006

Parts List AA-11
Components List AA-12

CONTROL P.C.B. ASSEMBLY 19-0007

Parts List AA-13
Components List AA-14

INTERCONNECTING P.C.B. ASSEMBLY 19-0008

Parts List AA-15
Components List AA-16 *

500MHz A.F.C. ASSEMBLY 11-0000

Parts List AA-17
Components List AA-18

Illustrations

Fig.

EXPLANATORY DIAGRAMS

Simplified Functional Diagram of Assembly AA-1
Input Trigger Characteristics AA-2
Overall Frequency Response: Range 1A AA-3
Overall Frequency Response: Range 1B AA-4
Overall Frequency Response: Ranges 0, 2, 3 and 4 AA-5
Detector Characteristic AA-6
Auxiliary Low-pass Filter Response: AFC4 AA-7
Functional Block Diagram: AFC5 AA-8
Auxiliary Low-pass Filter Response: AFC5 AA-9
Input Trigger (AFC7): Circuit and Waveforms AA-10
Sequencing Generator (AFC7): Circuit and Waveforms AA-11
And-gate (AFC7): Circuit and Waveforms AA-12

* To be issued later

Delay Generator (AFC7): Circuit and Waveforms AA-13
Control Flip-Flop (AFC7): Circuit and Waveforms AA-14
Auxiliary Reset Generators (AFC7): Circuits and Waveforms AA-15
Main Reset Generator (AFC7): Circuit and Waveforms AA-16
Control Sequence Waveforms for 500MHz AFC Assembly 11-0000 (Input signal between 202MHz and 302MHz) AA-17

X10 MULTIPLIER P.C.B. ASSEMBLY 19-0001

Component Layout AA-18 *
Circuit Diagram AA-19

HARMONIC SELECTOR P.C.B. ASSEMBLY 19-0002

Component Layout AA-20 *
Circuit Diagram AA-21

BALANCED MIXER P.C.B. ASSEMBLY 19-0003

Component Layout AA-22 *
Circuit Diagram AA-23

100MHz AMPLIFIER P.C.B. ASSEMBLY 19-0004

Component Layout AA-24 *
Circuit Diagram AA-25

FILTER, GATE AND DETECTOR P.C.B. ASSEMBLY 19-0005

Component Layout AA-26 *
Circuit Diagram AA-27

SHIFT REGISTER P.C.B. ASSEMBLY 19-0006

Component Layout AA-28 *
Circuit Diagram AA-29

CONTROL P.C.B. ASSEMBLY

Component Layout AA-30 *
Circuit Diagram AA-31

INTERCONNECTING P.C.B. ASSEMBLY

Component Layout AA-32 *
Circuit Diagram AA-33 *

500MHz AFC ASSEMBLY 11-0000

Component Layout AA-34 *
Detailed Block Diagram AA-35

* To be issued later

INTRODUCTION

Function

1. The 500MHz A.F.C. Assembly 11-0000 is designed to be used with a Racal 100MHz counter to provide direct, automatic and continuous frequency measurement over the range 2MHz to 500MHz. Combined with the Racal 2MHz to 102MHz Bi-Quinary Scaler P.C.B. Assembly 19-0049, it enables the same facilities to be obtained using a 10MHz counter.

Brief Electrical Specification

2. The principal design characteristics of the assembly are as follows:-

Frequency Range	2MHz to 500MHz
Input Impedance	50 ohm
Sensitivity	100mV r.m.s.
Input Attenuator	X10
Maximum Input Level	5V r.m.s.
Maximum Search Time	0.5 seconds
Output Frequency	2MHz to 102MHz
Output Level	100mV r.m.s. into 50 ohm
Reset and Search	Automatic or Manual
Accuracy	Same as that of external reference frequency
Reference Frequency	10MHz
Reference Level	200mV r.m.s. into 50 ohm
Operating Temperature	0 degrees C to 45 degrees C
Power Supplies	+12V d.c. -12V d.c.

GENERAL TECHNICAL DESCRIPTION

FUNCTIONAL BREAKDOWN

3. For the purposes of the following general technical description, the overall circuit of the assembly is broken down as follows:-

(a) Signal Circuits

(i)	X10 Frequency Multiplier	AFC1
(ii)	Harmonic Selector	AFC2

	(iii)	Balanced Mixer	AFC3
	(iv)	100MHz Wideband Amplifier	AFC4
	(v)	Filter, Gate and Detector	AFC5
(b)	Control Circuits		
	(i)	Shift Register	AFC6
	(ii)	Input Trigger	AFC7
	(iii)	Sequencing Generator	
	(iv)	And-gate	
	(v)	Control Flip-Flop	
	(vi)	Auxiliary Reset Generators	
	(vii)	Main Reset Generator	

SIGNAL CIRCUITS

NOTE:- The operation of the signal circuits of the assembly is described with reference to the explanatory diagrams Figs. AA-1 to AA-9 inclusive, the control sequence waveform diagram Fig. AA-17 and the detailed block diagram of the assembly, Fig. AA-35.

General Principles of Operation

4. The 10MHz reference frequency input to the assembly is multiplied in frequency in the X10 multiplier (AFC1) and harmonic selector (AFC2) circuits of the assembly to provide reference harmonics at 100MHz, 200MHz, 300MHz and 400MHz (Fig. AA-1). One of these four reference harmonics is gated by a pulse from the six-bit shift register (AFC6) in the control circuit section of the assembly (see also Figs. AA-17 and AA-35) for mixing in a balanced mixer (AFC3) with the input signal frequency (f_s). The mixer product required is the difference or lower sideband frequency, i.e. the signal frequency (f_s) minus the gated reference harmonic (f_o). This difference frequency ($f_s - f_o$) is then passed to a 100MHz wideband amplifier (AFC4) and a low-pass filter (AFC5 - see also Fig. AA-8) both of which severly attenuate those frequencies which are unacceptable to the counter or scaler-and-counter (10MHz application of the assembly) whichever the case may be.

5. Assume for example that the signal frequency under measurement is 222MHz. The requirement in order to measure this particular frequency correctly is for the shift register (AFC6) to gate the one particular reference harmonic which will beat with the signal frequency to produce a difference frequency of 22MHz. Clearly, this condition is fulfilled when the shift register (AFC6) gates the reference harmonic at 200MHz, i.e. the one immediately below the signal frequency.

6. The reference harmonic immediately below the signal frequency is not, however, the only one capable of beating with it to produce a response which is acceptable to the counter. If for example the shift register (AFC6) were to gate the 300MHz reference harmonic instead of that at 200MHz, the difference frequency fed to the wideband amplifier (AFC4) would then be the reference harmonic at 300MHz minus the signal frequency at 22MHz, i.e. 78MHz. Instead of the anticipated frequency measurement display of 222MHz, the counter/converter combination would, under these conditions, register the signal frequency incorrectly as 378MHz.

7. In this particular assembly, the problem of ensuring that the reference harmonic generation circuits always locks on when the correct response is obtained and never to the incorrect one, is solved by making the shift register (AFC6) scan the X10 multiplier (AFC1) and harmonic selector (AFC2) circuits twice. The initial or 'A' scan is terminated immediately the balanced mixer (AFC3) produces a response acceptable to the counter, whether it be the correct response or the incorrect one as defined in the foregoing paragraph. From the reference harmonic setting in effect at the moment of termination, the shift register (AFC6) and the reference harmonic generation circuits it controls are all reset to state zero (0MHz) in readiness for the start of the second or 'B' scan.

8. On the 'B' scan, the shift register (AFC6) gates the reference harmonics in ascending order of frequency, i.e. 100MHz, 200MHz, 300MHz and finally 400MHz. Immediately the balanced mixer (AFC3) produces a response acceptable to the counter, the 'B' scan is terminated. The response to which the control circuits have now locked must be the correct one since the required reference harmonic (f_o immediately below f_s) must now always be gated to the balanced mixer (AFC3) before, and never after, the unwanted one (f_o immediately above f_s).

9. An important feature of the 'B' scan is that it takes place at a higher sensitivity (compared with the 'A' scan) in order to ensure that the control circuits respond to the first genuine d.c. level to appear at the output of the detector (AFC5 - see Fig. AA-8). Because of the difficulty of maintaining a loop response over the i.f. bandwidth of better than ±1dB, the loop sensitivity of the 'B' scan is increased by approximately 3dB referred back to the signal input terminals of the balanced mixer (AFC3).

Suppression of Unwanted Responses

10. So far only the required output of the balanced mixer, i.e. the signal frequency (f_s) minus the gated reference harmonic (f_o), has been considered. In addition to this output ($f_s - f_o$) various other outputs do, of course, exist and these can be of significance whenever f_s and f_o are near to or within the i.f. bandwidth of the signal circuits.

11. Consider for example the case where f_s is equal to 104MHz and f_o is equal to 100MHz. Discounting the required output of the balanced mixer ($f_s - f_o$) other significant outputs are present as follows.

(1)	(2)	(3)	(4)	(5)	(6)
f_s	f_o	f_o+f_s	$2f_s$	$2f_o$	2nd and 3rd order sum and difference frequencies
104	100	204	208	200	

NOTE: All frequencies are in MHz.

12. Of the output frequencies listed, (3), (4), (5) and (6) are either (a) well outside the passband of the signal circuits or (b) too low in level to be of any significance. Outputs (1) and (2) however are likely to interfere with the operation of the counter and have to be suppressed. This is achieved with the aid of high-pass and low-pass auxiliary filters in the wide-band amplifier (AFC4) and filter, gate and detector (AFC5) sections of the signal channel, as follows.

13. In going from state zero (0MHz) to state 4 (400MHz), the shift register scans the 100MHz reference harmonic circuit in the harmonic selector not once as it does the others but twice (Fig. AA-17 illustrates this action). On the first of these two scans, a d.c. level is fed from edge connection 6/5 on the shift register (1) via feed-through capacitor C11 to terminal 1 in the wideband amplifier and (2) via resistor R4 and feedthrough capacitor C15 to terminal 3 in the filter, gate and detector (these details are given in Fig. AA-35). If Fig. AA-8 (block diagram of AFC5) and Fig. AA-25 (circuit diagram of AFC4) are now referred to, it will be seen that in each case the d.c. level input from the shift register is used to switch into operation a low-pass auxiliary filter circuit.

14. The overall effect of switching into circuit the low-pass auxiliary filters on AFC4 and AFC5 can be assessed from the idealised response curves depicted in Fig. AA-3. Response curve (1) shows that signals to the counter are attenuated at 100MHz by the low-pass auxiliary filter on AFC4. The response as seen by the detector (see also Fig. AA-8) is modified not only by the low-pass auxiliary filter in AFC4 but also by the low-pass auxiliary filter in AFC5 (response curve (2) of Fig. AA-3). The composite response seen by the detector (curve (3)) is therefore always equal to or enclosed by the response as seen by the counter. At the frequencies stipulated in paragraph 11, any leakage of the reference harmonic f_o (100MHz) or of the signal frequency f_s (104MHz) would, under these conditions, be considerably reduced.

15. The composite response as seen by the detector stage ensures that a range-change action occurs before the signal level to the counter falls too low. The range-change action will take place in the region where the input signal frequency f_s is equal to 180MHz.

16. On the second scan of the 100MHz reference harmonic circuit in the harmonic selector, a d.c. level is fed from edge connection 6/8 on the shift register via feedthrough capacitor C13 to terminal 2 in the filter, gate and detector (for these details see Fig. AA-35). As shown in Fig. AA-8 (block diagram of AFC5) this d.c. level is used to bring into operation a high-pass auxiliary filter circuit.

17. The idealised response curve of Fig. AA-4 shows that the response now seen by the detector has a point of high attenuation in the region of 10MHz. If the input frequency under measurement had been increased from its original value of 104MHz to a new value of 180MHz, then a range-change action would take place, resulting in a lock-on on the second scan of the 100MHz reference harmonic circuit in the harmonic selector (range 1B) instead of the first (range 1A). Conversely, assuming the signal frequency was originally 180MHz, then if it had subsequently been decreased in frequency to say 104MHz, a range-change would take place in the region of 110MHz. Under these conditions lock-on would occur on the first scan of the 100MHz harmonic circuit (range 1A) and not on the second (range 1B).

18. As can be seen from Fig. AA-6, the lock-on and fall-out points are on the linear part of the detector characteristic. Any unwanted signals of the type referred to in paragraphs 11 to 14 produce only a very low level signal at the input of the detector and are thus confined to the lower part of the curve. Any d.c. output produced by the detector from such a signal will be below the level necessary to trigger the control and scanning circuits of the assembly to bring the system into lock.

Operation in the Range 2MHz to 102MHz

19. The heterodyne principle of operation of the assembly does not apply to signal frequencies in the range 2MHz to 102MHz. Input signals within these limits are acceptable to the counter as they are, i.e. without change in frequency. The mode of operation of the signal channel circuits of the assembly in the presence of a signal frequency in this category is as follows.

20. The -12V supply for the X10 multiplier (AFC1) comes from the -12V power supply rail in the shift register (AFC6) via edge-connection 6/4, feedthrough capacitor C1 and control terminal 1 of AFC1 (confirmation of these details can be obtained from Figs. AA-19, AA-29 and AA-35). Whenever the shift register (AFC6) comes round to state zero (0MHz), the change of state in the 0 stage of the register cuts the -12V supply at edge-connection 6/4 off, thereby making AFC1 completely inoperative. With the X10 multiplier inoperative, there can be no input to the harmonic selector (AFC2) and therefore no reference harmonic input to the mixer (AFC3).

21. Mixer Unbalance At the same time as the d.c. voltage level at edge-connection 6/4 on the shift register goes to zero, the level at edge-connection 6/2 changes from zero volts to a negative level (-4V approximately). This change in level is fed via feedthrough capacitor C8 to control terminal 1 on the balanced mixer AFC3 (this can be checked from Fig. AA-35). In AFC3 the negative level cuts-off one of the two mixer diodes (D1 in Fig. AA-23) leaving the circuit in an unbalanced condition. Since the mixer is no longer balanced, the signal frequency (f_S) is no longer suppressed at the output and is instead now fed straight through the mixer to the following stages in the signal channel and thence to the counter.

Signal Gating

22. In order that the frequency measurement display on the counter may be latched to the 'hundreds-of-megahertz' display on the converter, the difference frequency output of the wideband amplifier (f_s-f_o) is fed to the low-pass filter output circuit of the signal channel via a gate (Fig. AA-8). Control of this gate is effected by the sequencing generator d.c. level output fed via edge-connection 7/4 on the main control board (AFC7) and feedthrough capacitor C16 to terminal 1 on AFC5 (Fig. AA-35).

23. The signal gate is opened and the difference frequency fed through the low-pass filter to the counter when, at the end of the 'B' scan of the control circuits, the d.c. output level at edge-connection 7/4 (0V) falls to approximately -5V. The gate remains open until such time as either (1) the input signal is disconnected or (2) its amplitude or its frequency changes sufficiently to cause the d.c. output level of the detector to fall below the second lower threshold level of the input trigger circuit on AFC7 (point 'd' on Fig. AA-2).

CONTROL CIRCUITS

NOTE:- The operation of the control circuits of the assembly is described with reference to the explanatory diagrams Figs. AA-2 to AA-5, Fig. AA-8, the control sequence waveforms diagram Fig. AA-17 and the detailed block diagram of the assembly, Fig. AA-35.

General Operation

24. Assume that the AUTO/MANUAL switch on the front panel of the converter is set to AUTO. The output of the detector circuit on AFC5 (Fig. AA-8) is fed via feedthrough capacitor C18 and the converter SHIFT/RECOUNT and AUTO/MANUAL front panel controls (SA and SB respectively) to the input trigger circuit on AFC7 (Fig. AA-35). When this output exceeds the first upper threshold level of the trigger circuit (point 'a' on Fig. AA-2) the circuit operates.

25. The operation of the input trigger circuit produces a change in the level of its output to the sequencing generator (waveform 1 of Fig. AA-17, at time t_3) as a result of which the sequencing generator is inhibited. When the sequencing generator stops, its output to the and-gate changes in a negative direction (waveform 2, at time t_3. The input to the and-gate from the control flip-flop is also a negative d.c. level at this time (waveform 7) and so the and-gate, which responds to negative level inputs but not to positive ones, operates.

26. When the sequencing generator is inhibited therefore, the change in level in its output to the and-gate is reproduced in the and-gate output to the delay generator (waveform 4, at time t_3). As soon as the level of the and-gate output changes, the delay generator is triggered. When the delay generator triggers, it produces a change in the level of its output to the main reset generator (waveform 6, at time t_3). Immediately this change in level of the delay generator output occurs, the main reset generator triggers.

27. Returning to the start of this sequence of events, i.e. the point at which the d.c. level output of the detector circuit in AFC5 (Fig. AA-8) exceeded the first upper threshold level of the input trigger circuit, it can be seen

that the effect of this on the shift register (AFC6) is twofold. First, since the sequencing generator has been inhibited and, as a result, its output to the shift register changed from a train of pulses to a steady d.c. level (waveform 3, at time t_3), the shift register stops cycling. Secondly, since the main reset generator has been triggered and, consequently, its output to the shift register changed from a positive level to a negative one (waveform 11, at time t_3), the shift register undergoes a reset action.

28. When the shift register resets, its output to the X10 frequency multiplier (AFC1) changes in a positive direction (waveform 12, at time t_3), thereby rendering the multiplier inoperative. With the multiplier switched off, its output to the harmonic selector (AFC2) falls to zero (waveform 18, at time t_3). Since the multiplier output is zero, the harmonic selector output to the balanced mixer (AFC3) must be the same (waveform 19, at time t_3).

29. The signal channel circuits of the assembly have thus changed over from (1) a condition in which the input signal frequency beats in the balanced mixer (AFC3) with the gated reference harmonic to produce a difference frequency response acceptable to the counter, to (2) one in which the signal frequency is fed to the balanced mixer on its own. The changeover from the first of these two conditions to the second causes the d.c. level at the output of the detector circuit on AFC5 (Fig. AA-8) to fall to zero. When this happens, a further train of events is triggered off as follows.

30. When the d.c. level output of the detector in AFC5 falls below the first lower threshold level of the input trigger (point 'b' on Fig. AA-2) this circuit reverts to its original condition. The change this brings about in the trigger output to the sequencing generator (waveform 2, between times t_3 and t_4) removes the inhibit from this circuit, thus allowing it to start up again. No further changes take place in the control system until the delay generator reverts to its original stable state. When this happens, the level of its output to the control flip-flop changes in a positive direction (waveform 5, approximately 3mS after time t_3). This causes the control flip-flop to trigger, with the result that (1) its output to the and-gate changes in a positive direction (waveform 7) and (2) its output to the auxiliary reset generators common output line changes in a negative direction (waveform 8). Output (1) inhibits the and-gate and output (2) removes the inhibit on auxiliary reset generator 'A'. Output (2) is also fed back to the input trigger circuit (Fig. AA-35) where it lowers the threshold levels of the circuit (Fig. AA-2, points 'c' and 'd'), thereby increasing its sensitivity.

31. Since the sequencing generator has started up again, its output to the shift register (AFC6) is restored (waveform 3 of Fig. AA-17). On the first positive-going edge of the sequencing generator output, the change in the shift register output to the X10 frequency multiplier AFC1 (waveform 12) effectively reconnects this to its -12V supply, thereby rendering the circuit operative again (waveform 18). This particular edge of the sequencing generator output also makes the next output of the shift register, i.e. the first of its two outputs to the X1

frequency multiplier circuit in the harmonic selector AFC2 (waveform 13). The change in this output of the shift register switches the X1 frequency multiplier circuit on, thereby causing the harmonic selector output to the balanced mixer (AFC3) to change from 0MHz to the reference harmonic at 100MHz (waveform 19).

32. Succeeding positive-going edges of the sequencing generator output to the shift register (AFC6) change each of its other four outputs to the frequency multiplier circuits of AFC2 (waveforms 14 to 17 inclusive of Fig. AA-17) until the output fed to the balanced mixer (AFC3) is the reference harmonic immediately below the signal frequency. Assuming the signal frequency to be within the range 202MHz to 302MHz, the input to the mixer from the harmonic selector would then be the reference harmonic at 200MHz (waveform 19, starting at time t_4). The difference frequency response produced by beating this reference harmonic with the signal frequency ($f_s - f_o$) restores the d.c. level at the output of the detector circuit in AFC5 (Fig. AA-8). When this d.c. level output exceeds the second upper threshold level of the input trigger circuit (Fig. AA-2, point 'c') the trigger circuit operates for the second time in the control cycle.

33. Conditions as far as the sequencing generator circuit is concerned are now the same as when the input trigger circuit was operated before (time t_3 of Fig. AA-17) that is to say the sequencing generator is inhibited and its output to the and-gate is a negative d.c. level (waveform 2, at time t_4). This time, however, the and-gate circuit is inhibited, since the control flip-flop output to the gate is positive and not negative (waveform 7, at time t_4). As there is thus no and-gate output to trigger the delay generator and therefore no delay generator outputs to trigger the control flip-flop and the main reset generator, the state of these three control circuits remains unchanged. The control circuits have now locked on with the shift register (AFC6) stopped and the X10 frequency multiplier (AFC1) and harmonic selector (AFC2) circuits delivering to the balanced mixer (AFC3) the reference harmonic at 200MHz (waveforms 12 to 19 of Fig. AA-17, from time t_4).

Auxiliary Reset 'A' Action

34. Signal Level Change Assume that, some time after the control circuits have locked on, the input signal is subject to a reduction in level sufficient to cause the output of the detector circuit of AFC5 to fall below the second lower threshold level of the input trigger circuit (point 'd' on Fig. AA-2). As soon as the output of the detector falls below this level, the input trigger circuit will revert to its original untriggered condition. The trigger output to the sequencing generator will then change in a negative direction (waveform 2 of Fig. AA-17, at time t_5) removing the inhibit from this circuit and thus allowing it to start up again.

35. The trigger circuit output is also fed to auxiliary reset generator 'A', which, since it is no longer inhibited by the control flip-flop (para. 29), inverts the trigger pulse. The inverted trigger pulse output of auxiliary reset generator 'A' (waveform 10, at time t_5) triggers the main reset generator. The resulting reset pulse (waveform 11, at time t_5) resets not only the shift register (AFC6) but also the control flip-flop.

36. Since the control flip-flop has been reset, its outputs to the and-gate, the input trigger circuit (Fig. AA-35) and the auxiliary reset generators common output line all revert to the levels shown in Fig. AA-17, waveforms 7 and 8 respectively, at times t_1 and t_5. As the control flip-flop output to the and-gate changes back to a negative d.c. level, the gate circuit changes from its inhibited condition back to being primed. The change in the second of the two control flip-flop outputs has two effects. First, it restores the inhibit on the output of auxiliary reset generator 'A', thereby ensuring that this remains inoperative during normal operations of the input trigger circuit. Secondly, it reinstates the input trigger circuit threshold levels, and therefore the circuit sensitivity, to their original values (points 'a' and 'b' on Fig. AA-2). The control circuits will remain in this condition until such time as the level of the input signal is once again sufficient to cause the d.c. output of the detector to rise above the level necessary to operate the input trigger circuit. When this happens, the sequence of events described in paragraphs 24 to 32 is repeated until finally the control circuits lock on again as described in paragraph 33.

37. Signal Frequency (Range) Change Apart from the features of the signal channel amplifier and filter response characteristics covered in paras. 14 and 17, the idealised response curves of Figs. AA-3, AA-4 and AA-5 all show that the lower sideband response (f_s-f_o) falls off significantly in the region of 2MHz and again at approximately 104MHz. If the input signal is subject to a change in frequency sufficient to shift the lower sideband response out of this 102MHz pass-band, then the output of the detector circuit in AFC5 will fall below the second lower threshold level of the input trigger circuit (point 'd' on Fig. AA-2). Provided that the control circuits are locked on at the time the signal frequency changes, then the change will cause them to reset as described in the foregoing paragraphs. The control circuits do not remain in in the reset condition but recycle as described in paragraphs 24 to 32 until finally they lock on to the new signal frequency (para. 33).

Auxiliary Reset 'B' Action

38. The main reset action which terminates the 'A' scan(s) and starts off the 'B' scan is preceded by an auxiliary reset action similar to that described in paras. 35 and 36. The first of these two auxiliary reset actions differs from the second in that it is automatic and initiated solely by the action of auxiliary reset generator circuit 'B' (Fig. AA-17).

39. Auxiliary reset generator 'B' triggers approximately 1 second after the converter power supplies are switched on (time t_o in Fig. AA-17). The reset 'B' output to the main reset generator changes in a positive direction (waveform 9, at time t_1) thereby causing the main reset generator circuit to operate. The resulting reset pulse (waveform 11, at time t_1) resets the shift register (AFC6) and the control flip-flop. With the control flip-flop in its reset condition, the input trigger, and-gate and auxiliary reset generator 'A' circuits are all in their correct initial states. This ensures that when the d.c. output level of the detector circuit in AFC5 rises above the first upper threshold level of the input trigger circuit, the control system operates in the manner described.

Manual Operation

40. Assume that the AUTO/MANUAL switch on the front panel of the converter is set to MANUAL. Instead of being connected to the output of the detector circuit in AFC5 as it was before, the input of the input trigger circuit is now connected via SB1 (Fig. AA-35) to the junction point of the two resistors, R1 and R2, connected across the +12V power supply. Since the potential at this point (+2.5V approximately) is greater than the first upper threshold level of the input trigger circuit (+1.5V approximately) the trigger circuit is held in its operated condition. The function of the sequencing generator, which is now inhibited, is taken over by a differentiating circuit in AFC7 switched into circuit by SB2 and triggered (from the -12V supply) by means of the SHIFT/RECOUNT push-button switch SA. When the push-button is depressed, a single positive-going edge is fed to the shift register, causing it to advance from whichever state it happens to be in at the time to the next highest in the sequence.

41. A further function of the mode switch in manual operation is to ensure that the digit display power supply, which is controlled by the control flip-flop, is switched on. Normally, the -12V power supply for the digit lamps is switched on when the control flip-flop is triggered and off when it is reset. In the MANUAL position of the mode switch, the control flip-flop is held in its triggered condition and, consequently, the digit lamps -12V power supply held ON, by earthing (via SB3) the control flip-flop output at edge connection 7/8 (Fig. AA-35).

42. The SHIFT/RECOUNT switch SA also has its use in the automatic mode of operation of the converter, which is as a reset control. In the AUTO position of the mode switch, depressing the push-button control disconnects the input trigger circuit (at SA contacts 1 and 2 - Fig. AA-35) from the output of the detector circuit in AFC5. In the absence of an input, the trigger circuit reverts to its original (untriggered) condition, causing the control circuits to reset in the manner described in paras. 34 to 36.

DETAILED TECHNICAL (CIRCUIT) DESCRIPTION

X10 MULTIPLIER AFC1 (Fig. AA-19)

43. The 10 MHz reference frequency input is multiplied in frequency in the X5 circuit comprising diode D1, inductor L2 and capacitor C6, and again in the X2 circuit D2, L4, C12 (Fig. AA-19). To obtain the increased signal level necessary for the correct operation of these circuits, each multiplier is preceded by a conventional class A r.f. amplifier tuned to the appropriate frequency. The 100 MHz output is provided at the required level by means of the 100 MHz tuned r.f. amplifiers Q3 and Q4. The 100 MHz is taken from a tapping on the inductive element of the output tuned circuit to provide the required impedance match.

44. The 10 MHz input is terminated by resistor R1 in parallel with potentiometer control RV1, which, in conjunction with the circuit tuning, is used to set the output to the required level. A bias of about -3.3V is impressed on the base of Q1 from the potential divider R2, R3 and the effect of this is to set the

emitter current of the stage to approximately 11.5 mA. The gain of the stage is stabilized by the feedback resistor in the emitter circuit, R4, the emitter load being provided by R5, by-passed by C3. Stages Q2, Q3 and Q4 are identical to Q1 except for the fact that their tuned circuits, being tuned to 50 MHz and 100 MHz, have different circuit values.

45. In the X5 and X2 circuits the multiplicative function is obtained by exploiting the particular property of the type of diode used, namely, its ability to develop an output waveform with a very fast rise-time when biased to operate in a certain mode; the diode is in each case self-biased to operate in this mode by a resistor of appropriate value (e.g. R6). The required harmonic is extracted from the harmonic spectrum present in this output waveform by the passive-tuned circuit of the multiplier (i.e. 5th harmonic of 10 MHz from L2, C6 and 2nd harmonic of 50 MHz from L4, C12).

46. Tuning is effected throughout the board by means of ferrite slugs. When all the tuned circuits are peaked, the 100 MHz output is adjusted to the required level by means of potentiometer RV1. This preset level adjustment facility is necessary because of the existing tolerances in the circuit parameters, especially those of the two diodes D1 and D2.

47. The -12V supply to each stage on the board incorporates a ferrite bead and associated decoupling capacitor (e.g. X1 and C5) to prevent interaction between stages via the -12V supply line.

HARMONIC SELECTOR AFC2 (Fig. AA-21)

48. The function of the harmonic selector board is to multiply the 100MHz reference harmonic input by a factor of either 1, 2, 3 or 4, depending on the conditions existing at the four numbered control terminals of the board. The multiplier circuits and their associated 100 MHz amplifiers are similar to those used in the X10 Multiplier AFC1 (Part No. 19-0001). In AFC2, however, the r.f. amplifiers are also used to facilitate selection of the required output frequency.

49. The base of each transistor in this assembly is set to a level of the order of -3.3V by menas of the potential divider R2, R3 (Fig. AA-21). The gain of Q1 at 100 MHz is stabilized by the feedback resistor in the emitter circuit, R4; this increases the input impedance of the stage and makes it less dependent on the parameters of the transistor. The emitter load for Q1 is provided by R4, which is by-passed by C2. The collector circuit is broadly tuned to 100 MHz by the ferrite-cored inductor L1 in parallel with capacitors C3 and C4; C3 is the effective tuning capacitance, while C4 is included to isolate the diode biasing resistor R6 from the collector of the transistor. Stages Q2, Q3 and Q4 are similar to Q1, but since it is not required to drive a multiplier circuit, Q4 has a slightly different collector circuit arrangement. The capacitance tuning arm of this circuit comprises capacitors C12 and C13, which form a potential divider. Resistor R14 across the smaller of these two capacitors (C12) provides a d.c. return for the switching diode D1.

50. In each harmonic selector stage, the amplifier transistor is operative when its associated control terminal (1, 2, 3 or 4) and thus the junction point of its emitter resistors, is left free to fall to the level set by the base biasing resistors R2, R3 (the emitter current of the amplifier transistor under these conditions is of the order of 11.5 mA). Conversely, if its control terminal is held at about 0V, the same circuit is inoperative, its base-emitter junction then being reverse-biased by about -3.5V to turn the transistor 'off'. Consider the case where the existing states on the control lines 1 to 4 are such that Q1 is operative and Q2, Q3 and Q4 are inoperative. With the potential at the junction of R4, R5 free to fall to about -4V (the level determined by R2, R3) the junction of R21, R22 becomes slightly negative (-0.4V) which is sufficient to maintain diode D7 in a forward-biased condition. The 400 MHz signal frequency present at the tapping on the secondary winding of the X4 multiplier transformer T3 is thus fed through D7 and C14 to the common output terminal. The base-emitter junctions of Q2, Q3 and Q4, meanwhile, are reverse-biased by about -3.5V, thus making the junctions at the cathodes of diodes D5, D3 and D1 slightly positive (+1.3V). Any residual outputs at 100 MHz, 200 MHz and 300 MHz from the collector of Q1 and the X2 and X3 multiplier transformers (though Q2, Q3 and Q4 are inoperative, signals at a very low level are fed through the base-collector capacitances of the transistors) are now further attenuated in D1, D3 and D5 thus ensuring optimum purity in the frequency selected.

BALANCED MIXER AFC3 (Fig. AA-23)

51. This assembly uses two diodes in a double-balanced mixer circuit to ensure that both the signal frequency and the reference harmonic frequency are suppressed at the output (Fig. AA-23). To provide the necessary balanced drive to the mixer diodes D1 and D2, wideband unbalance-to-balance transformers T1 and T2 are used on both the signal and reference harmonic frequency inputs.

52. The combination of resistors R1, R2, R3, capacitor C2 and the shunting effect of the diodes provides an input impedance of the order of 50 ohms over the input frequency range 2 MHz to 500 MHz. The bias current in the mixer diodes is provided by resistors R4 to R7 and potentiometer RV1; RV1 is adjusted for maximum common mode rejection within the i.f. band 2 MHz to 102 MHz.

53. The non-linearity of the mixer diodes results in an output containing products at frequencies corresponding to the sum and the difference of its signal and reference harmonic frequency inputs. These products are coupled through to the output terminal of the assembly via capacitors C3 and C4.

54. With input frequencies in the range 2 MHz to 102 MHz the d.c. level at pin 1 is changed from zero volts to a negative voltage, thereby cutting off diode D1. The input signal now passes through diode D2 only, and, since suppression no longer takes place because of the mixer unbalance, the signal passes directly to the output.

100 MHz AMPLIFIER AFC4 (Fig. AA-25)

55. This assembly consists of an input emitter-follower (Q1) and a wideband amplifier (Q2-Q4) providing 35 dB of gain at an overall bandwidth of 110 MHz (Fig. AA-25).

56. The input to Q1 is terminated by resistor R4. Resistor R3 and R5 bias the base of Q1 to about +0.6V, the emitter current under these conditions being of the order of 17 mA. The collector load resistor R7 is decoupled by capacitor C5 and the +12V and -12V supply rails by R6, C4 and R9, C7 respectively.

57. Inductor L1 and capacitor CT1 in the input circuit of Q1 form an auxiliary low-pass filter. The bottom end of R2 in the filter switching circuit R1, R2, D1 is taken via terminal 1 to the shift register AFC6. Terminal 1 can be at either 0V or -4V, depending on the particular state of the shift register in being at any given time (0V applies in all states except 1A - see section on AFC6). With the terminal at 0V, resistors R1 and R2 reverse-bias the diode D1, thereby in effect placing a high impedance in series with L1, CT1. Thus, although L1, CT1 is tuned to series resonance at 100 MHz, its effect in the circuit is negligible under these conditions. When terminal 1 is at 0V, the converse of this action occurs, i.e. D1 is forward-biased and a very low impedance placed in series with the filter. Under these conditions signals at the input are significantly attenuated, resulting in a reduction of the overall gain by some 15 dB at 100 MHz.

58. The first of the wideband amplifier stages, Q2, is typical of the amplifier circuit arrangement as a whole. Resistors R10 and R11 bias the base of the transistor to about 0.6V, resulting in a standing emitter current of the order of 17 mA and a collector voltage of about +6V. The stage is tuned by means of the trimmer capacitor CT2 connected in parallel with the fixed by-pass capacitor C10 across R14; the emitter load resistor R15 is by-passed by capacitor C11. The +12V supply for Q2 is decoupled from the other four stages by R12, C8.

FILTER, GATE AND DETECTOR AFC5 (Fig. AA-27)

59. The signal frequency input to this assembly is fed in parallel (1) to the gate stage Q1 and (2) to buffer Q2, the main low-pass filter, buffer Q3, the auxiliary high and low-pass filters and detector D3, D4 (Fig. AA-27). In the gate stage the junction of R2 and R3 in the emitter of Q1 is taken via terminal 1 to control board assembly AFC7. Terminal 1 can be at either 0V or -6V, depending upon whether or not a signal is present (0V corresponds to the no-signal condition). The -6V condition signifies that Q1 is conducting normally, the junction of R2, R3 then being left free to take up the base potential of the transistor, as set by the potential divider R4, R5; under these conditions, the signal at the input terminal of the board is fed via Q1 and its associated low-pass filter to the output terminal OUTPUT 1. When terminal 1 is at 0V (no-signal condition), Q1 is turned 'off' and no signal is fed to the low-pass filter and OUTPUT 1. Resistor R2 in the gate stage helps to stabilize the gain, particularly at low frequencies. C5 is the by-pass capacitor for the emitter load R3.

60. The auxiliary low-pass filter in the output of Q1 has a sharp cut-off at 102 MHz and provides additional protection from interference signals of 102 MHz and above. If this filter were not included, false readings might well appear on the counter when the input signal to the converter is something of this order, say, 105 MHz. Under these conditions, in addition to the wanted signal frequency output (5 MHz), the unwanted signal frequency component at 105 MHz superimposed on this would also be fed to the counter. As it is, the filter removes the 105 MHz component and passes the wanted 5 MHz signal through to the counter. The gate stage Q1 has a nominal voltage gain of 1 and so provides, in addition to the gating, buffering facilities for the filter.

61. Resistor R6 in the input has a two-fold function, i.e. (1) it terminates the output of the preceding wideband amplifier board, AFC4, and (2) it provides a d.c. return path for the base current of Q2. Q2 is another grounded-emitter stage and is included to buffer the main low-pass filter from the input circuit and also from the auxiliary low-pass filter on the output of Q1. Resistor R8 in the emitter of Q2 is by-passed by C8 to provide high-frequency boost. The main emitter load resistor R9 is by-passed by C9.

62. The input end of the main low-pass filter contains a matching arrangement C10, R11, R10. The filter proper comprises L2, C13, C12 etc. which is m-derived and has a very sharp cut-off at 102 MHz. The filter is terminated by R12 mainly, which also serves to provide a d.c. return path for the base current of Q3.

63. Q3 is a grounded-emitter stage similar to Q2 but with an emitter-peaking facility (CT1 in parallel with C21). This stage buffers the auxiliary high and low-pass filters from the main low-pass filter.

64. Capacitor C20, C23, C24 and inductor L6 form a simple high-pass filter in the output of Q3, L6 being adjusted so as to attenuate signal frequencies below 2 MHz. Signals above this frequency are passed by the filter through to the detector diodes D3 and D4. In effect these diodes form a simple voltage doubler and the d.c. voltage developed at the cathode of D4 is taken to output terminal OUTPUT 2.

65. The auxiliary high and low pass filters across the input of the detector (L7, C25 and L8, C26) are switched in and out of circuit by AFC6 in a similar fashion to the auxiliary filter in the 100 MHz amplifier AFC4 (see section on AFC4). The auxiliary high-pass filter is series resonant at approximately 10 MHz but its effect in the circuit is neglible except when the diode is forward-biased (state 1B of the shift register); under these conditions the reduced impedance of the diode allows current to pass through the filter and any signals which are passed through the main filter and buffer Q3 are attenuated at 10 MHz. Similarly, the auxiliary low-pass filter, which is series resonant at about 90 MHz, is effective only when diode D2 is forward-biased (state 1A of the shift register); in this case any signals passing through the main filter and buffer are attenuated at approximately 90 MHz before being passed to the detector.

SHIFT REGISTER (AFC6) (Fig. AA-29)

Inputs

66. The shift register p.c.b. assembly 19-0006 (circuit diagram Fig. AA-29) is designed to accept any one of three different inputs:

(a) A reset pulse,

(b) shift pulses, or

(c) a carry level.

67. Reset Pulse Input This input originates in the main reset generator circuit of the control p.c.b. assembly 19-0007 (AFC7). The 21V nominal peak-to-peak pulse (approximate upper and lower limits +12V and -9V respectively) is d.c. coupled (1) via resistor R10 to the base of the right-hand transistor of flip-flop 0 (Q3) and (2) via resistors R13, R22 etc., to the bases of the left-hand transistors in all the other flip-flops (Q6, Q10 etc.). The negative-going edge of the pulse turns all these transistors 'on', thereby causing the register to take up the condition known as state zero (0). The states of the individual transistors following a reset pulse are shown in tabular form on page AA-19.

68. Shift Pulses Input This consists of the output of the sequencing generator circuit in AFC7 differentiated by capacitor C5 on that assembly (see Fig. AA-31) and resistors R50 and R51 in the shift register assembly (Fig. AA-29). The line on which the differentiated positive and negative going shift pulses appear is coupled via diodes D4, D8 etc., to the bases of the right-hand transistors of all of the flip-flops (Q3, Q8 etc.). Whenever any one of these transistors is conducting, its base, and therefore the cathode of the associated diode, is slightly negative. When the positive-going shift input pulse exceeds the reverse bias on the diode (the diode anodes all receive a standing bias of -6V from the junction of resistors R50 and R51) the diode conducts and the transistor is turned 'off'.

69. Carry Level Input This consists of the positive-going level change at Q18 collector when this transistor is turned 'on', fed back to the input of the register via an external linkage on the interconnecting p.c.b. assembly 19-0008 (AFC8 - see Fig. AA-35). From the point at which it is fed back into the shift register again (terminal 1 on Fig. AA-29) the carry level is coupled, via a differentiating circuit and a steering diode (C1, R2 and D1) to the base of transistor Q1 in flip-flop 0. When this transistor is conducting, the d.c. levels at its base and its collector are such that the steering diode is biased in a forward direction. Consequently, if a carry level is present, this will be fed through the steering diode to Q1 base, thus causing the transistor to be turned 'off'.

Circuit Operation

70. Assume that the shift register has been reset to state zero (0) as described in paragraph 67. The first positive-going shift pulse to occur following a reset action turns transistor Q3 of flip-flop 0 'off'; all the other transistors to which the shift input is applied are 'off' already, hence flip-flop 0 is the only circuit affected by this particular shift pulse. Since Q3 of flip-flop 0 has been turned 'off', Q1 in this circuit must now be conducting. As transistor Q1 comes 'on', a positive-going edge similar to the carry level input appears at Q1 collector, which, again like the carry level input, is a.c. coupled via a differentiating circuit and a steering diode (C2, R14 and D5) to the base of the following transistor, Q6. Since Q6 is conducting, the steering diode D5 is forward-biased, consequently the positive-going edge at the collector of Q1 passes through the diode to Q6 base thus causing Q6 to be turned 'off'. The register has now changed from its initial state zero(0) condition to the condition known as state 1A.

SHIFT REGISTER (AFC6): TABLE OF STATES

FLIP-FLOP	TRANSISTORS	0	1A	1B	2	3	4	0
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
0	Q1	−	+	+	+	+	+	−
	Q3	+	−	−	−	−	−	+
1A	Q6	+	−	+	+	+	+	+
	Q8	−	+	−	−	−	−	−
1B	Q10	+	+	−	+	+	+	+
	Q11	−	−	+	−	−	−	−
2	Q12	+	+	+	−	+	+	+
	Q14	−	−	−	+	−	−	−
3	Q15	+	+	+	+	−	+	+
	Q17	−	−	−	−	+	−	−
4	Q18	+	+	+	+	+	−	+
	Q20	−	−	−	−	−	+	−

NOTE:- In the above table the plus signs indicate the transistors which are conducting and the minus signs those which are non-conducting.

71. The second shift input pulse to occur after a reset action has taken place changes the state of flip-flops 1A and 1B in exactly the same way as the first shift input pulse changed the states of flip-flops 0 and 1A. This type of action continues with the third, fourth and fifth shift input pulses, which change the states of flip-flops 1B and 2, 2 and 3, and 3 and 4 respectively. Conditions at the end of the fifth shift input pulse are such that when the sixth pulse occurs, the effect on the register is the same as that of applying a reset pulse, i.e. the register is returned to the state from which it started, namely, state zero (0).

Control Functions

72. The changes of state in the various flip-flop circuits as the register runs through a complete cycle is used to bring about changes in the a.f.c. assembly and converter display unit operating conditions as follows.

73. Flip-flop 0 Assume this circuit to be in the second of its stable states, i.e. the state Q1 fully 'on', Q3 fully 'off'. In order to get the circuit to change back to its initial stable state, transistor Q1 must receive a carry level input from flip-flop 4 (via the linkage on AFC8) or, alternatively, transistor Q3 must receive a reset pulse from the main reset generator circuit in AFC7. As soon as either of these two inputs is received, current starts to flow out of Q3 emitter into the base-emitter junction of transistor Q2. When Q3 is fully 'on' Q2 'bottoms' thus causing the voltage at Q2 collector to fall to zero. The collector of Q2, however. is coupled (1) via diode D2 to the '0' bulb in the converter display unit and (2) via emitter-follower Q4 to the -12V power supply input terminal on the X10 frequency multiplier p.c.b. assembly 19-0001 (AFC1). Consequently, the result of Q2 'bottoming' is, first, that current flows out of the register, through D2 to the '0' bulb thus turning this 'on' and, secondly, that the voltage at the -12V power supply input terminal of AFC1 falls to zero, thereby making this assembly inoperative.

74. As flip-flop 0 changes back to its initial stable state, the change in transistor Q3 is accompanied by a similar but opposite change in the condition of transistor Q1. The diminishing current in Q1 collector circuit makes the voltage at the junction of resistors R3 and R4 increase until, eventually, when Q1 is turned fully 'off', it reaches approximately -4V. Now the collector of Q1 is also connected, via resistor R6, to the anode of one of the two mixer diodes in the balanced mixer p.c.b. assembly 19-0003 (AFC3). Hence, as Q1 goes 'off' the -4V level which appears on its collector also appears at the anode of the appropriate mixer diode in AFC3. When this happens, the mixer diode affected cuts-off, thereby causing the mixer to operate in an unbalanced mode instead of a balanced one.

75. The '0' bulb has a common connection with all the other digit bulbs in the converter display unit. This common connection is taken to the emitter of emitter-follower Q14 in the control flip-flop circuit of AFC7. Depending on the state of the control flip-flop the voltage level at Q14 emitter

is either 0V (control flip-flop reset, digit display 'off') or -12V (control flip-flop triggered, digit display 'on'). When the 0V level is present, diode D2 in the shift register prevents Q3 collector from taking up a similar level, which in turn prevents spurious cut-offs in the -12V power supply to AFC1.

76. When the 0 flip-flop is triggered back again from its first to its second stable state, the circuit operation described in the foregoing paragraphs is carried out again but in the reverse sense. This means that (1) the '0' bulb in the converter display unit goes 'off', (2) the -12V d.c power supply to AFC1 is restored and thus the assembly made operative again and (3) the mixer assembly AFC3 returns to its normal (balanced) mode of operation.

77. Flip-flops 1A and 1B These two flip-flop circuits are complementary to each other. In the 1A circuit, the collector of the left-hand transistor, Q6 is coupled (1) via the 'or' gate diode D6 to the 100MHz circuit in the harmonic selector p.c.b. assembly 19-0002 (AFC2) and (2) via emitter-follower Q5 to the low-pass auxiliary filter circuits in amplifier p.c.b. assembly 19-0004 (AFC4) and filter-gate-detector p.c.b. assembly 19-0005 (AFC5). The collector of the corresponding transistor in the 1B circuit, on the other hand, is coupled (1) to the 100MHz circuit in AFC2 via the second 'or' gate diode, D10 and (2) via another emitter-follower (Q9) to the high-pass auxiliary filter circuit in AFC5. On the right-hand side of the two flip-flops, the emitters of transistors Q8 and Q11 are both connected to the base of transistor Q7, which drives directly into the '1' bulb in the converter display unit.

78. The 1A and 1B flip-flops are basically the same circuit as the 0 flip-flop. This being the case, when these two circuits are triggered, the collector voltages on their left-hand transistors (Q6 and Q10) increase to about -4V as these are turned 'off', whilst the currents in the emitters of their right-hand transistors (Q8 and Q11) increase to a maximum as these go fully 'on'.

79. In the 1A flip-flop, the appearance of the -4V edge at Q6 collector has two main effects, namely, (1) it turns 'on', via the 'or' gate diode D6, the 100MHz circuit in AFC2 and (2) it switches into circuit, via emitter-follower Q5, the low-pass auxiliary filters in AFC4 and AFC5. The corresponding event in the 1B flip-flop has similar effects, i.e. (1) it turns 'on' the 100MHz circuit in AFC2 via the other half of the 'or' gate, diode D10, and (2) it switches into circuit, via emitter-follower Q9, the high-pass auxiliary filter in AFC5. The increased currents flowing in the emitters of transistors Q8 and Q9 when these are turned 'on' have the same effect externally, i.e. they turn 'on', via transistor Q7, the '1' digit bulb in the converter display unit.

80. When the 1A and 1B flip-flops of the register are returned to their initial stable states, the foregoing control functions are carried out in reverse, i.e. (1) the 100MHz circuit in AFC2 is turned 'off', (2) the '1' digit bulb in the converter display unit is turned 'off' and (3) the low-pass and high-pass auxiliary filters in AFC4 and AFC5 are switched out of circuit.

81. Flip-flops 2, 3 and 4 The collector load resistors of transistors Q12, Q15 and Q18 of flip-flops 2, 3 and 4 are located in the emitter circuits of the 200MHz, 300MHz and 400MHz selector stages of AFC2, where they provide the bias necessary to turn these stages 'on' and 'off' as required. The three right-hand transistors of these flip-flops have their emitters coupled, via identical drive stages (Q13, Q16 and Q19) to the '2', '3' and '4' digit bulbs respectively in the converter display unit.

82. With their collector load resistors connected, flip-flops 2, 3 and 4 are identical to flip-flops 0, 1A and 1B. The -4V edge which occurs at the collectors of the left-hand transistors when the flip-flops are triggered turns the 200MHz, 300MHz and 400MHz in AFC2 'on'. The current drive from the emitters of the right-hand transistors into the bases of Q13, Q16 and Q19 turns the '2', '3' and '4' digit bulbs 'on'. When the flip-flops are returned to their original stable states these operations are carried out again but this time in the opposite sense, i.e. the frequency selector circuits in AFC2 and the digit bulbs in the converter display unit are all turned 'off'.

CONTROL ASSEMBLY (AFC7)

Circuit Breakdown

83. The control p.c.b. assembly 19-0007 (AFC7) contains the following circuits;-

(a)	Input trigger	Fig. AA-10
(b)	Sequencing generator	" AA-11
(c)	And-gate	" AA-12
(d)	Delay generator	" AA-13
(e)	Control flip-flop	" AA-14
(f)	Auxiliary reset generators	" AA-15
(g)	Main reset generator	" AA-16

Input Trigger

84. The input trigger circuit comprises an emitter-follower (Q1), a Schmitt trigger (Q1, Q2) and a trigger level (sensitivity) control stage (Q4).

85. The base of the emitter-follower, Q1, is coupled directly to the output of the detector circuit in AFC5. Resistor R12 in the trigger level control circuit is connected to the junction of resistors R32 and R33 in the collector (output) circuit of transistor Q10 of the control flip-flop.

86. Initially, i.e. under 'A' scan conditions, (1) the detector output level to Q1 base is zero volts, (2) transistor Q10 in the control flip-flop is turned fully 'on'. In the Schmitt trigger circuit, in its quiescent

state, the left-hand transistor, Q2, is 'on' (Q5 base slightly positive) and the right-hand transistor, Q3, 'off'. In the trigger level control circuit, the level at the emitter of Q4 is of the order of +2V (set by potentiometer RV1).

87. Prior to the transition from 'A' to 'B' scan conditions, the detector output increases in proportion to the level of the signal which the detector then receives from the signal channel circuits preceding it. When this output level reaches +1.5V, Q2 in the Schmitt trigger circuit is made to cut-off and the circuit changes over to the state Q2 'off', Q3 'on'. Following the start of the 'B' scan, conditions in the signal channel circuits of the a.f.c. assembly are such that the detector output once again falls to zero. When the falling detector output reaches the lower trigger level of the Schmitt, the trigger circuit is forced back to its original condition, i.e. Q2 'on', Q3 'off'.

88. Approximately 3mS after the start of the 'B' scan, the delay generator reverts to its stable state and the resulting circuit output triggers the control flip-flop, which thus takes up the state Q10 'off', Q12 'on'. As Q10 goes 'off', it alters the level at the emitter of Q4 in the trigger level control circuit to approximately 1.25V (this level is set by potentiometer RV2).

89. Prior to the end of the 'B' scan, the output of the detector once more increases in proportion to the level of the signal fed to it from the 100Mhz wideband amplifier AFC4. When the detector output reaches +0.95V, transistor Q2 in the Schmitt trigger circuit is forced 'off' again and the circuit becomes stable with Q2 cut-off and Q3 conducting. The Schmitt remains in this condition until such time as there is a change in the frequency or the amplitude of the signal at the input of the detector sufficient to cause the detector output level to fall below the second lower lower threshold level of the input trigger circuit. When this happens, the Schmitt trigger is forced back to its original stable state ('A' scan conditions again) and the control flip-flop is reset. With the control flip-flop reset, Q10 in this circuit comes back 'on' again and the emitter of Q4 in the trigger level control circuit returns to its original level (+2V approximately). Consequently, when the input trigger circuit does operate again it does so at the higher of its two trigger level settings, i.e. at +1.5V instead of +0.95V.

90. Circuit Outputs The input trigger circuit provides two outputs, namely, (1) the output to the sequencing generator gate from the collector of Q3 of the Schmitt and (2) that to auxiliary reset generator 'A', also from the collector of Q3. The direct effects of these outputs are described in the paragraphs dealing with the circuits concerned.

Sequencing Generator (Fig. AA-11)

91. The sequencing generator (Fig. AA-11) comprises an astable flip-flop (Q6, Q7) and a transistor gate (Q5).

92. Circuit Operation The base of the gate transistor, Q5, is coupled, via the potential divider R10, R13, to the output of the Schmitt section of the input trigger circuit (Q3 collector). Initially, i.e. under 'A' scan

conditions, the trigger circuit output level fed to the potential divider on Q5 base is approximately -9V, the gate is open (Q5 base-emitter junction forward-biased) and the flip-flop free-runs. At the end of the 'A' scan, when the input trigger circuit is operated, the level at Q3 collector rises to about +1V, the sequencing generator gate closes (Q5 base emitter junction reverse-biased) and the flip-flop stops. Shortly after it is operated, the input trigger circuit is forced back to its original condition, the sequencing generator gate re-opens and the flip-flop starts up again. At the end of the 'B' scan, when the input trigger circuit is re-operated, the sequencing generator gate closes again and the flip-flop stops. The sequencing generator circuit remains in this condition until such time as there is a change in the amplitude or the frequency of the signal at the input of the detector circuit in AFC5 sufficient to cause the input trigger circuit to operate again. When this happens, the trigger circuit reverts to its 'A' scan condition and the circuit action just described is repeated.

93. External Outputs In the sequencing generator gate, the collector of Q5 is coupled, via resistor R18, to the signal gate circuit in AFC5. When the first-named gate is open (Q5 collector at a level of approximately 0V) the signal gate is closed. Conversely, when the sequencing generator is closed (Q5 collector at about -5V) the gate on AFC5 is open.

94. In the sequencing generator flip-flop, Q7 collector is coupled via capacitor C5 to the shift pulse input line in AFC6. When the flip-flop is free-running its 35mS output waveform is differentiated by C5 and two resistors to which it is connected in AFC6, thus causing the shift register to operate. When the sequencing generator flip-flop stops, the output at Q7 collector becomes a steady d.c. level and the shift register in AFC6 ceases to operate.

95. Internal Output The sequencing generator circuit provides one internal output, namely, the output to the And-gate circuit from the collector of transistor gate, Q5. The direct effect of this output is described in the following paragraphs.

And-gate (Fig. AA-12)

96. The And-gate circuit (Fig. AA-12) comprises just two diodes (D2 and D3) and a resistor (R21).

97. Circuit Operation The anode of diode D2 is coupled directly to the collector of the sequencing generator gate transistor, Q5. The anode of diode D3 is coupled directly to the collector of the right-hand transistor, Q12, of the control flip-flop. Initially, i.e. under 'A' scan condition, (1) Q5 collector, and thus the anode of diode D2, is at 0V, (2) Q12 collector, and thus the anode of diode D3, is at -10V. As D2 is now forward-biased, the output of the gate under these conditions is negligible.

98. At the end of the 'A' scan, when the voltage at Q12 collector is still at -10V, Q5 collector falls to -6V, taking the output of the and-gate with it. Shortly after it falls to -6V, the level at Q5 collector returns to 0V,

restoring the forward-bias on diode D2, thus causing the and-gate output to become negligible again. When the control flip-flop resets later on in the 'B' scan, Q12 collector goes to 0V, diode Q3 becomes forward-biased thus causing the gate to be inhibited. At the end of the 'B' scan, Q5 collector returns to its -6V level, but since the level at Q12 collector is still 0V, the and-gate remains inoperative. The and-gate remains in this condition until such time as there is a change in the frequency or the amplitude of the signal at the input of the detector circuit in AFC5 sufficient to cause the control flip-flop to be reset. When this happens, Q12 collector returns to its original level (-10V) and the circuit action just described is repeated.

99. Circuit Output The and-gate output is fed directly to the input of the delay generator circuit, where its effect is as described in the following paragraphs.

Delay Generator (Fig. AA-13)

100. Together with their associated components, the delay generator transistors Q8 and Q9 (Fig. AA-13) form a monostable flip-flop.

101. Circuit Operation The base of the left-hand transistor, Q8, of the delay generator flip-flop, is coupled, via diode D4 and the differentiating circuit C6, R22, to the output of the and-gate circuit. Initially, i.e. under 'A' scan conditions, the and-gate output is at a fixed potential of approximately -0.5V. In the delay generator flip-flop, in its quiescent state, (1) transistor Q9 is held 'on' by the current fed into its base via resistor R28, and (2) transistor Q8 is held 'off' by the small positive bias applied to its base-emitter junction from the potential divider R23, R25 and R27.

102. When the and-gate operates at the end of the 'A' scan, the level fed to the input of the delay generator flip-flop falls sharply towards -6V. This negative-going edge is differentiated by C6, R22 and then fed, via diode D4 to the base of transistor Q8. This transistor is thus made to conduct, thereby causing the flip-flop to take up its quasi-stable state, namely, Q8 'on', Q9 'off'. Capacitor C8, once it is fully charged, discharges through resistor R28, until, after 3mS approximately, the flip-flop reverts to its original (stable) condition. The circuit will remain in this condition until such time as there is a change in the amplitude or the frequency of the signal at the input of the detector circuit in AFC5 sufficient to result in the resetting of the control flip-flop. When this happens, the and-gate will operate again at the end of the next 'A' scan and the circuit operation just described will be repeated.

103. Circuit Outputs The delay generator circuit provides two outputs, namely, (1) the output to the control flip-flop from the collector of transistor Q9, and (2) that to the main reset generator circuit from the collector of transistor Q9. The direct effects of these two outputs are described in the paragraphs immediately following and in those dealing with the main reset generator circuit.

Control Flip-flop (Fig. AA-14)

104. Basically, this is just a straightforward bistable flip-flop (Q10, Q12) equipped with differentiating input circuits and steering gates (C9, R30, D5 and C12, R38, D7). The two other stages associated with the control flip-flop (Q11 and Q13, Q14) have to do with the operation of the converter display unit and are dealt with separately.

105. Circuit Operation The base of transistor Q10 of the control flip-flop is coupled (1) via resistor R29 to the output of the main reset generator and (2) via steering diode D5 and differentiating circuit C9, R30, to the output of the delay generator. Initially, that is to say at the start of the 'A' scan, the main reset generator is triggered. The resulting reset pulse is fed, via R29, to the base of Q10, where the negative-going edge of the pulse turns the transistor 'on'. The control flip-flop is thus now in the stable state Q10 'on', Q12 'off'. On the changeover from 'A' to 'B' scan conditions, the main reset generator circuit is triggered again, but this time the reset pulse has no effect on the control flip-flop as this has not left its reset condition. Later on in the 'B' scan, when the delay generator reverts to its original (stable) state, the resulting positive-going edge, differentiated by C9 and R30 and subsequently fed via diode D5 to Q10 base, turns this transistor 'off'. The control flip-flop stays in the condition Q10 'off', Q12 'on' until such time as there is a change in the amplitude or the frequency of the signal at the input of the detector circuit in AFC5 sufficient to reult in the main reset generator circuit being re-triggered. When this happens, the resulting reset pulse returns the control flip-flop to its original (reset) condition as already described, subsequent to which the circuit is triggered again at the appropriate point in the 'B' scan, by the output of the delay generator.

106. Circuit Outputs The control flip-flop provides five outputs, i.e. three from the left-hand transistor, Q10, and two from the right-hand transistor, Q12. The outputs from Q10 consists of the two outputs from the collector circuit of the transistor, namely, (1) the output to the input trigger circuit and (2) the output, via diode D8, to the auxiliary reset generator 'A' circuit, plus the output from the emitter of Q10, fed to the base of transistor Q11. Both the outputs from Q12 of the flip-flop come from the collector of the transistor, one being the output to the and-gate, the other the output fed via resistor R41 to the base of transistor Q13. The effect of the outputs fed to the input trigger and and-gate circuits has been described already in the sections dealing with these particular circuits. The effect of the outputs to transistors Q11 and Q14 is dealt with in the paragraphs immediately following and that of the output to auxiliary reset generator 'A' in the section following this.

107. Transistors Q11, Q13 and Q14 are concerned with the operation of the converter display unit. Resistor R36 in the collector circuit of Q11 is connected to one end of the 'check level' lamp, its other end being connected to -12V in the display unit. The emitter of transistor Q14 is connected to the common line terminals of the digit lamps in the display unit, the other sides of the lamps being connected to the collectors of the digit bulb drive

transistors in AFC6. Under 'A' scan conditions, i.e. when transistor Q10 of the control flip-flop is 'on', transistor Q11 is also 'on' and this supplies the necessary current to the operate the 'check level' lamp in the display unit. The collector voltage of the 'off' transistor (Q12) holds the grounded-emitter stage Q13 'on', with the result that both base and emitter of the emitter-follower Q14 are at a potential of the order of 0V, and the digit display is thus 'off'. Conversely, when the left-hand transistor of the flip-flop, Q10, is turned 'off' ('B' scan conditions), Q11 is turned 'off' thus making the 'check level' display inoperative, and (2) Q13 is turned 'off', thus causing the collector to fall to -12V, which fall is then transferred by the emitter-follower action of Q14 to reactivate the digit display.

Auxiliary Reset Generators

108. There are two auxiliary reset generator circuits, viz:-

(a) Auxiliary reset generator 'A'
(b) Auxiliary reset generator 'B'

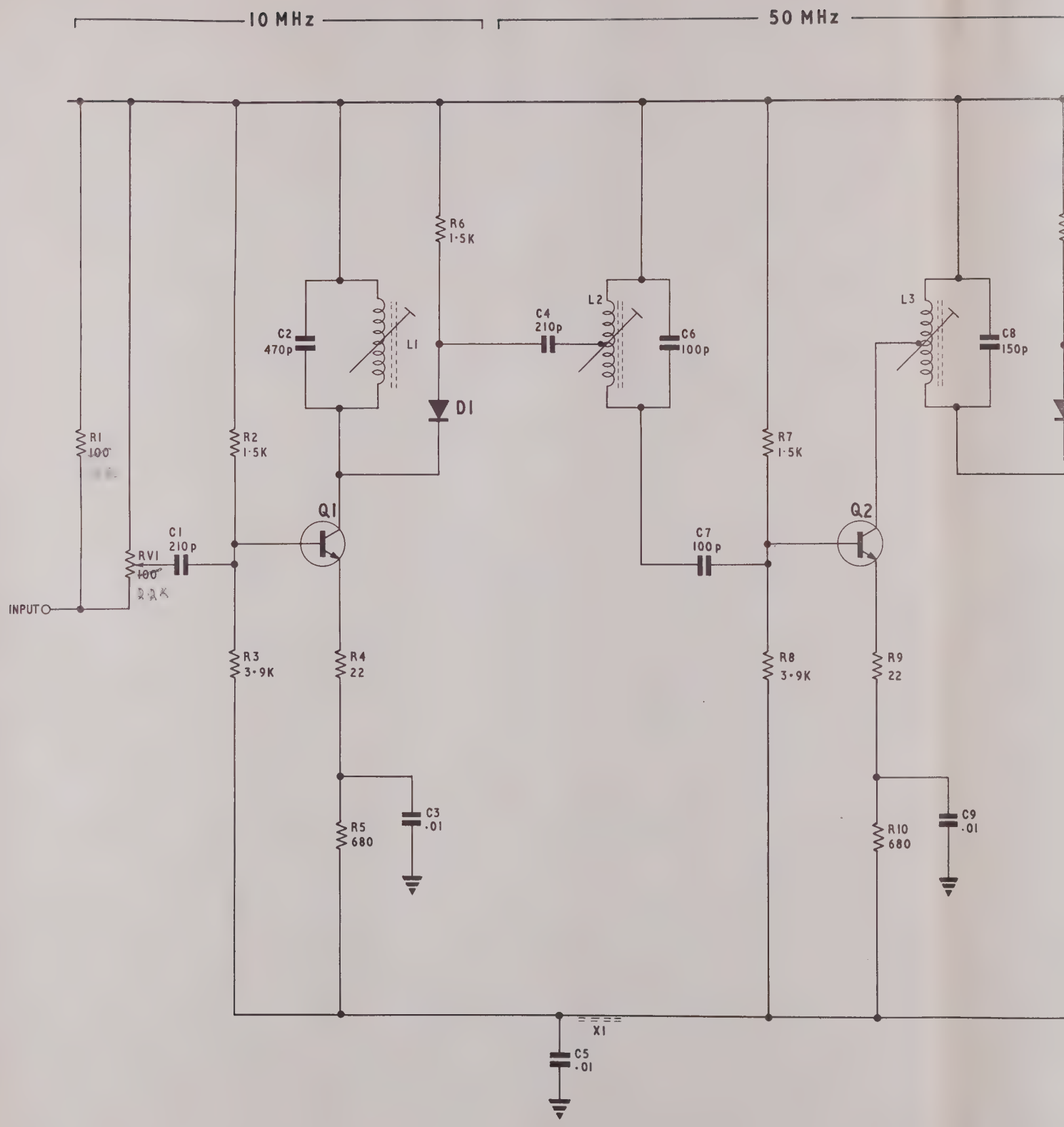
109. Auxiliary Reset Generator 'A' The base of transistor Q15 is coupled via resistor R45 to the output of the input trigger circuit (Q3 collector). The collector of Q15 is coupled via diode D8 to the collector of transistor Q10 in the control flip-flop. Under 'A' scan conditions, the level at Q3 collector in the input trigger circuit is about -9V, whilst the level fed to Q15 collector via D8 is approximately 0V. At the end of the 'A' scan, the first-named level goes to +1V approximately, but as Q15 collector is still held at 0V by the control flip-flop output, there is no change at this point. Later on in the 'B' scan, the control flip-flop is triggered and the output at Q10 collector falls to -10V. At the end of the 'B' scan, the output of the input trigger circuit goes sharply positive to approximately +1V. As the inhibit level applied to the collector of Q15 has now been removed, the positive-going edge from the input trigger circuit is inverted and appears at Q15 collector as a 12V negative-going edge.

110. Auxiliary Reset Generator 'B' The base of transistor Q16 is fed from the time constant circuit C13,R47. When the power supplies for the circuit come 'on', C13 charges up and holds Q16 'off' for the time (one second approximately) Q16 base takes to fall from +12V to approximately +5V. When the base potential of Q16 reaches +5V, the transistor comes 'on' and a positive-going 12V edge is developed at its collector.

Main Reset Generator (Fig. AA-16)

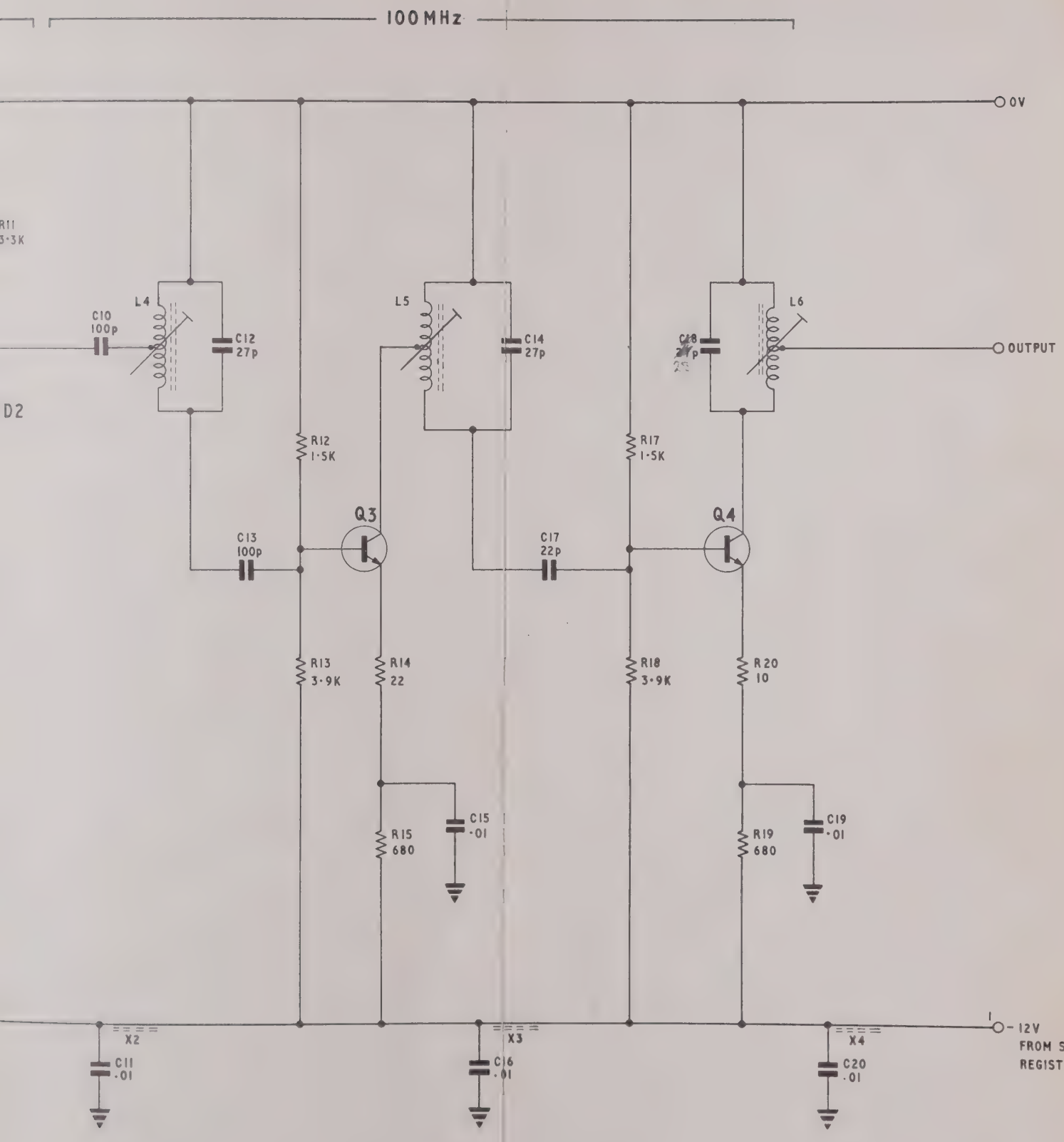
111. The base of the main reset generator transistor, Q17, is connected (1) via resistor R53 to the -12V supply and (2) via the three coupling circuits R49, C16, R50, C17 and R48, C15 to the outputs of the delay generator and both auxiliary reset generators. The operation of the main reset circuit is the same for all three inputs, i.e. the positive-going edge of the incoming pulse turns the transistor 'off' (normally it is held 'on' by the current flowing into its base via resistor R53) thus causing its collector to fall sharply negative from

+12V to approximately -9V. When the circuit has recovered through R53, the transistor comes back 'on' again, thus causing the voltage at the collector to return again to its original level, namely, +12V



19-0001
1	

Circuit: X10



Multiplier P.C.B. Assembly 19-0001 (AFC 1)

Fig. AA-19

TABLE AA-1

PARTS LIST

X10 MULTIPLIER P.C.B. ASSEMBLY 19-0001

(A.F.C.1)

Item No.	Part No.	Description	Qty.	Vendor *
1	17-3000	Coil Assembly	1	
2	17-3001	Coil Assembly	1	
3	17-3002	Coil Assembly	1	
4	17-3003	Coil Assembly	1	
5	17-3004	Coil Assembly	1	
6	17-3005	Coil Assembly	1	
7				
8				
9				
10	18-0001	Board P.C.	1	
11				
12				
13				
14	20-0100	Resistor Comp 1/10W 10% 10		
15	20-0101	Resistor Comp 1/10W 10% 100	1	
16	20-0152	Resistor Comp 1/10W 10% 1.5K	1	
17	20-0220	Resistor Comp 1/10W 10% 22	3	
18	20-0332	Resistor Comp 1/10W 10% 3.3K	1	
19	20-2152	Resistor MO 1/4W 5% 1.5K	4	
20	20-2392	Resistor MO 1/4W 5% 3.9K	4	
21	20-2681	Resistor MO 1/4W 5% 680	4	
22				
23				
24	20-6510	Resistor Var 20% 100	1	
25				
26				
27	21-1565	Capacitor Cer 150V 10% 22p	1	
28	21-1573	Capacitor Cer 150V 10% 100p	3	
29	21-1590	Capacitor Cer 150V 10% 210p	2	
30	21-1591	Capacitor Cer 100V -20% +80% 0.01	8	
31	21-2507	Capacitor S/Mica 300V 5% 27p	3	
32	21-2521	Capacitor S/Mica 300V 5% 100p	1	
33	21-2525	Capacitor S/Mica 300V 5% 150p	1	
34	21-2537	Capacitor S/Mica 300V 5% 470p	1	
35	21-2505	Capacitor S/Mica 300V 5% 22p	1	
36				
37				
38	22-1004	Diode Si (specially Selected)	2	

* To be issued later

Item No.	Part No.	Description	Qty	Vendor *
39				
40				
41	22-6001	Transistor Si npn	4	
42				
43				
44	23-8000	Bead Ferrite	9	

* To be issued later

TABLE AA-2

COMPONENTS LIST

X10 MULTIPLIER P.C.B. ASSEMBLY 19-0001

(A.F.C.1)

Cct. Ref.	Parts List Reference Item	Table	Physical * Location Grids	Fig.
Resistors Fixed				
R1	15	AA-1		
R2	19	AA-1		
R3	20	AA-1		
R4	17	AA-1		
R5	21	AA-1		
R6	16	AA-1		
R7	19	AA-1		
R8	20	AA-1		
R9	17	AA-1		
R10	21	AA-1		
R11	18	AA-1		
R12	19	AA-1		
R13	20	AA-1		
R14	17	AA-1		
R15	21	AA-1		
R16				
R17	19	AA-1		
R18	20	AA-1		
R19	21	AA-1		
R20	14	AA-1		
Resistor Variable				
RV1	24	AA-1		
Diodes				
D1	38	AA-1		
D2	38	AA-1		
Transistors				
Q1	41	AA-1		
Q2	41	AA-1		
Q3	41	AA-1		
Q4	41	AA-1		

Cct. Ref.	Parts List Reference Item	Table	Physical * Location Grids	Fig.
Capacitors				
C1	29	AA-1		
C2	34	AA-1		
C3	30	AA-1		
C4	29	AA-1		
C5	30	AA-1		
C6	32	AA-1		
C7	28	AA-1		
C8	33	AA-1		
C9	30	AA-1		
C10	28	AA-1		
C11	30	AA-1		
C12	31	AA-1		
C13	28	AA-1		
C14	31	AA-1		
C15	30	AA-1		
C16	30	AA-1		
C17	27	AA-1		
C18	35	AA-1		
C19	30	AA-1		
C20	30	AA-1		
Inductors				
L1	1	AA-1		
L2	2	AA-1		
L3	3	AA-1		
L4	4	AA-1		
L5	5	AA-1		
L6	6	AA-1		
Ferrite Beads				
X1	44	AA-1		
X2	44	AA-1		
X3	44	AA-1		
X4	44	AA-1		

* To be issued later

TABLE AA-3

PARTS LIST

HARMONIC SELECTOR P.C.B. ASSEMBLY 19-0002

(A.F.C.2)

Item No.	Part No.	Description	Qty	Vendor *
1	13-0118	Screen	1	
2				
3				
4				
5	17-3006	Coil Assembly	1	
6	17-3007	Coil Assembly	3	
7	17-3008	Coil Assembly	2	
8	17-3009	Coil Assembly	2	
9	17-3010	Coil Assembly	2	
10				
11				
12				
13	18-0002	Board P.C.	1	
14				
15				
16	20-0103	Resistor Comp 1/10W 10% 10K	4	
17	20-0121	Resistor Comp 1/10W 10% 120	1	
18	20-0152	Resistor Comp 1/10W 10% 1.5K	4	
19	20-0220	Resistor Comp 1/10W 10% 22	4	
20	20-0472	Resistor Comp 1/10W 10% 4.7K	3	
21	20-0680	Resistor Comp 1/10W 10% 68	1	
22	20-2152	Resistor MO 1/4W 5% 1.5K	1	
23	20-2392	Resistor MO 1/4W 5% 3.9K	1	
24	20-2681	Resistor MO 1/4W 5% 680	3	
25				
26				
27				
28	21-1569	Capacitor Cer 150V - 10% 47p	1	
29	21-1571	Capacitor Cer 150V - 10% 68p	2	
30	21-1573	Capacitor Cer 150V - 10% 100p	2	
31	21-1575	Capacitor Cer 150V - 10% 150p	1	
32	21-1585	Capacitor Cer 150V - 10% 1Kp	7	
33	21-2580	Capacitor S/Mica 500V 5% 47p	4	
34	21-1591	Capacitor Cer 100V -20% +80% 0.01	1	
35				
36				
37	21-6001	Capacitor Trim 150V 0.5-5p	6	
38				
39				
40				
41	22-0000	Diode GE	2	
42	22-1002	Diode Si	2	
43	or			
44	22-1021	Diode Si		
45	22-1004	Diode (Specially Selected)	3	
46				
47	22-6001	Transistor Si npn	4	

* To be issued later

TABLE AA-4

COMPONENTS LIST

HARMONIC SELECTOR P.C.B. ASSEMBLY 19-0002

(A.F.C. 2)

Cct. Ref.	Parts List Reference Item	Table	Physical * Location Grids	Fig.
Resistors				
R1		AA-3		
R2	22	AA-3		
R3	23	AA-3		
R4	19	AA-3		
R5	24	AA-3		
R6	20	AA-3		
R7	19	AA-3		
R8	24	AA-3		
R9	20	AA-3		
R10	19	AA-3		
R11	24	AA-3		
R12	20	AA-3		
R13	19	AA-3		
R14	17	AA-3		
R15	24	AA-3		
R16	16	AA-3		
R17	18	AA-3		
R18	16	AA-3		
R19	18	AA-3		
R20	16	AA-3		
R21	18	AA-3		
R22	16	AA-3		
R23	21	AA-3		
Diodes				
D1	41	AA-3		
D2	45	AA-3		
D3	41	AA-3		
D4	45	AA-3		
D5	42	AA-3		
D6	45	AA-3		
D7	42	AA-3		
Inductors				
L1	6	AA-3		
L2	6	AA-3		
L3	6	AA-3		
L4	5	AA-3		
L5	7	AA-3		
L6	7	AA-3		
L7	8	AA-3		
L8	8	AA-3		
L9	9	AA-3		
L10	9	AA-3		

Cct. Ref.	Parts List Reference Item	Table	Physical * Location Grids	Fig.
Capacitors				
C1	30	AA-3		
C2	32	AA-3		
C3	33	AA-3		
C4	32	AA-3		
C5	33	AA-3		
C6	32	AA-3		
C7	32	AA-3		
C8	33	AA-3		
C9	32	AA-3		
C10	32	AA-3		
C11	32	AA-3		
C12	33	AA-3		
C13	29	AA-3		
C14	28	AA-3		
C15	29	AA-3		
C16	30	AA-3		
C17	31	AA-3		
C18	34	AA-3		
Capacitors Trim.				
CT1	37	AA-3		
CT2	37	AA-3		
CT3	37	AA-3		
CT4	37	AA-3		
CT5	37	AA-3		
CT6	37	AA-3		
Transistors				
Q1	47	AA-3		
Q2	47	AA-3		
Q3	47	AA-3		
Q4	47	AA-3		

* To be issued later

TABLE AA-5

PARTS LIST

BALANCED MIXER P.C.B. ASSEMBLY 19-0003

(A.F.C.3.)

Item No.	Part No.	Description				Qty.	Vendor *
1	18-0003	Board P.C.				1	
2							
3							
4							
5	20-0100	Resistor Comp	1/10W	10%	10	1	
6	20-0103	Resistor Comp	1/10W	10%	10K	2	
7	20-0223	Resistor Comp	1/10W	10%	22K	2	
8	20-0680	Resistor Comp	1/10W	10%	68	2	
9							
10							
11							
12	20-6503	Resistor Var		20%	10K	1	
13							
14							
15							
16	21-1504	Capacitor Cer	500V	10%	4.7p	1	
17	21-1505	Capacitor Cer	500V	10%	5.6p	1	
18	21-1591	Capacitor Cer	100V	+80% -20%	0.01	3	
19							
20							
21							
22	22-1018	Diode Si				2	
23							
24							
25	23-8001	Core-Ferrite				2	

* To be issued later

TABLE AA-6

COMPONENTS LIST

BALANCED MIXER P.C.B. ASSEMBLY 19-0003

Cct Ref.	Parts List Reference		Physical * Location		Cct. Ref.	Parts List Reference		Physical * Location	
	Item	Table	Grid	Fig.		Item	Table	Grid	Fig.
Resistors					**Diodes**				
R1	5	AA-5			D1	22	AA-5		
R2	8	AA-5			D2	22	AA-5		
R3	8	AA-5							
R4	6	AA-5							
R5	7	AA-5							
R6	7	AA-5			**Transformers**				
R7	6	AA-5			T1	25	AA-5		
					T2	25	AA-5		
Potentiometers									
RV1	12	AA-5							
Capacitors									
C1	17	AA-5							
C2	16	AA-5							
C3	18	AA-5							
C4	18	AA-5							
C5	18	AA-5							

* To be issued later

TABLE AA-7

PARTS LIST

100MHz AMPLIFIER P.C.B. ASSEMBLY 19-0004

(A.F.C.4.)

Item No.	Part No.	Description	Qty.	Vendor *
1	17-3018	Coil Assembly	1	
2				
3				
4				
5	18-0004	Board P.C.	1	
6				
7				
8				
9	20-0151	Resistor Comp 1/10W 10% 150	1	
10	20-0470	Resistor Comp 1/10W 10% 47	1	
11	20-0471	Resistor Comp 1/10W 10% 470	1	
12	20-0472	Resistor Comp 1/10W 10% 4.7K	1	
13	20-0820	Resistor Comp 1/10W 10% 82	4	
14	20-1000	Resistor Comp 1/10W 5% 27	2	
15	20-1001	Resistor Comp 1/10W 5% 33	1	
16	20-2222	Resistor MO 1/4W 5% 2.2K	4	
17	20-2271	Resistor MO 1/4W 5% 270	4	
18	20-2272	Resistor MO 1/4W 5% 2.7K	4	
19	20-3681	Resistor MO 1/2W 5% 680	4	
20				
21				
22				
23	21-1500	Capacitor Cer 500V 10% 2.2p	1	
24	21-1504	Capacitor Cer 500V 10% 4.7p		
25	21-1570	Capacitor Cer 500V -10% 56p	1	
26	21-1572	Capacitor Cer 500V -10% 82p	1	
27	21-1575	Capacitor Cer 500V -10% 150p	1	
28	21-1591	Capacitor Cer 100V +80% -20% 0.01	15	
29				
30				
31	21-6000	Capacitor Trim 250V 10-40p	4	
32				
33				
34				
35	22-1002	Diode Si	1	
36	22-6001	Transistor Si npn	4	

* To be issued later

TABLE AA-8

COMPONENTS LIST

100MHz AMPLIFIER P.C.B. ASSEMBLY 19-0004

(A.F.C.4)

Cct Ref.	Parts List Reference Item	Table	Physical * Location Grids	Fig.
Resistors				
R1	12	AA-7		
R2	11	AA-7		
R3	16	AA-7		
R4	9	AA-7		
R5	18	AA-7		
R6	13	AA-7		
R7	17	AA-7		
R8	19	AA-7		
R9	10	AA-7		
R10	16	AA-7		
R11	18	AA-7		
R12	13	AA-7		
R13	17	AA-7		
R14	14	AA-7		
R15	19	AA-7		
R16	16	AA-7		
R17	18	AA-7		
R18	13	AA-7		
R19	17	AA-7		
R20	15	AA-7		
R21	19	AA-7		
R22	16	AA-7		
R23	18	AA-7		
R24	13	AA-7		
R25	17	AA-7		
R26	14	AA-7		
R27	19	AA-7		
Capacitors Trim				
CT1	31	AA-7		
CT2	31	AA-7		
CT3	31	AA-7		
CT4	31	AA-7		

Cct. Ref.	Parts List Reference Item	Table	Physical * Location Grids	Fig.
Capacitors				
C1	23	AA-7		
C2	28	AA-7		
C3	28	AA-7		
C4	28	AA-7		
C5	28	AA-7		
C6	28	AA-7		
C7	28	AA-7		
C8	28	AA-7		
C9	28	AA-7		
C10	25	AA-7		
C11	28	AA-7		
C12	28	AA-7		
C13	28	AA-7		
C14	26	AA-7		
C15	28	AA-7		
C16	28	AA-7		
C17	28	AA-7		
C18	27	AA-7		
C19	28	AA-7		
Diodes				
D1	35	AA-7		
Transistors				
Q1	36	AA-7		
Q2	36	AA-7		
Q3	36	AA-7		
Q4	36	AA-7		
Inductors				
L1	1	AA-7		

* To be issued later

TABLE AA-9

PART LIST

FILTER AND GATE DETECTOR P.C.B. ASSEMBLY 19-0005

(A.F.C.5)

Item No.	Part No.	Description	Qty.	Vendor *
1	17-3011	Coil Assembly	1	
2	17-3012	Coil Assembly	2	
3	17-3013	Coil Assembly	2	
4	17-3014	Coil Assembly	1	
5	17-3015	Coil Assembly 20 g 6 TURNS	1	
6				
7				
8				
9	18-0005	Board P.C.	1	
10				
11				
12				
13	20-0103	Resistor Comp 1/10W 10% 10K	2	
14	20-0151	Resistor Comp 1/10W 10% 150	2	
15	20-0181	Resistor Comp 1/10W 10% 180	2	
16	20-0220	Resistor Comp 1/10W 10% 22	1	
17	20-0390	Resistor Comp 1/10W 10% 39	1	
18	20-0471	Resistor Comp 1/10W 10% 470	1	
19	20-0560	Resistor Comp 1/10W 10% 56	1	
20	20-0680	Resistor Comp 1/10W 10% 68	1	
21	20-1000	Resistor Comp 1/10W 5% 27	1	
22	20-1001	Resistor Comp 1/10W 5% 33	1	
23	20-2271	Resistor MO 1/4W 5% 270	2	
24	20-2472	Resistor MO 1/4W 5% 4.7K	1	
25	20-2681	Resistor MO 1/4W 5% 680	3	
26	20-2822	Resistor MO 1/4W 5% 8.2K	1	
27				
28				
29				
30	21-1500	Capacitor Cer 500V 10% 2.2p	1	
31	21-1565	Capacitor Cer 150V - 10% 22p	1	
32	21-1569	Capacitor Cer 150V - 10% 47p	1	
33	21-1573	Capacitor Cer 150V - 10% 100p	1	
34	21-1591	Capacitor Cer 100V + 80% - 20% 0.01	9	
35				
36	21-2501	Capacitor S/Mica 300V 5% 12p		
37	21-2503	Capacitor S/Mica 300V 5% 18p	1	
38	21-2505	Capacitor S/Mica 300V 5% 22p	3	
39	21-2507	Capacitor S/Mica 300V 5% 27p	1	
40	21-2509	Capacitor S/Mica 300V 5% 33p	1	

* To be issued later

Item No.	Part No.	Description				Qty	Vendor *
41	21-2513	Capacitor S/Mica	300V	5%	47p	2	
42	21-2537	Capacitor S/Mica	300V	5%	470p	3	
43	21-3500	Capacitor Polyn	30V	10 %	2.7Kp	1	
44							
45							
46							
47	21-6000	Capacitor Trim	250V		10-40V	1	
48							
49							
50							
51	22-1002	Diode Si				2	
52	or						
53	22-1021	Diode Si					
54	22-0002	Diode Si				2	
55							
56	22-6001	Transistor Si npn				3	
57							
58							
59	23-7002	Choke 10% 0.5m				1	

* To be issued later

TABLE AA-10

COMPONENTS LIST

FILTER, GATE AND DETECTOR P.C.B. ASSEMBLY 19-0005

(A.F.C.5)

Cct. Ref.	Parts List Reference		Physical * Location	
	Item	Table	Grids	Fig.
Resistors				
R1	18	AA-9		
R2	17	AA-9		
R3	25	AA-9		
R4	24	AA-9		
R5	26	AA-9		
R6	19	AA-9		
R7	23	AA-9		
R8	22	AA-9		
R9	25	AA-9		
R10	14	AA-9		
R11	14	AA-9		
R12	20	AA-9		
R13	21	AA-9		
R14	25	AA-9		
R15	23	AA-9		
R16	13	AA-9		
R17	15	AA-9		
R18	13	AA-9		
R19	15	AA-9		
R20	16	AA-9		
Capacitors Trim				
CT1	47	AA-9		
Diodes				
D1	51	AA-9		
D2	51	AA-9		
D3	54	AA-9		
D4	54	AA-9		
Transistors				
Q1	56	AA-9		
Q2	56	AA-9		
Q3	56	AA-9		

Cct. Ref	Parts List Reference		Physical * Location	
	Item	Table	Grids	Fig.
Capacitors				
C1	36	AA-9		
C2	39	AA-9		
C3	36	AA-9		
C4	34	AA-9		
C5	34	AA-9		
C6	34	AA-9		
C7	34	AA-9		
C8	31	AA-9		
C9	34	AA-9		
C10	33	AA-9		
C11	36	AA-9		
C12	40	AA-9		
C13	38	AA-9		
C14	41	AA-9		
C15	36	AA-9		
C16	41	AA-9		
C17	38	AA-9		
C18	38	AA-9		
C19	30	AA-9		
C20	22	AA-9		
C21	32	AA-9		
C22	34	AA-9		
C23	23	AA-9		
C24	22	AA-9		
C25	22	AA-9		
C26	37	AA-9		
C27	34	AA-9		
C28	34	AA-9		
C29	34	AA-9		
Inductors				
L1	1	AA-9		
L2	2	AA-9		
L3	3	AA-9		
L4	2	AA-9		
L5	3	AA-9		
L6	4	AA-9		
L7	59	AA-9		
L8	5	AA-9		

* To be issued later

TABLE AA-11

PART LIST

SHIFT REGISTER P.C.B. ASSEMBLY 19-0006

(A.F.C.6.)

Item No.	Part No.	Description				Qty.	Vendor *
1	18-0006	Board P.C.				1	
2							
3							
4							
5	20-0103	Resistor Comp	1/10W	10%	10K	9	
6	20-0183	Resistor Comp	1/10W	10%	18K	5	
7	20-0222	Resistor Comp	1/10W	10%	2.2K	6	
8	20-0333	Resistor Comp	1/10W	10%	33K	12	
9	20-0472	Resistor Comp	1/10W	10%	4.7K	6	
10	20-0822	Resistor Comp	1/10W	10%	8.2K	6	
11	20-2100	Resistor MO	1/4W	5%	10	1	
12	20-2221	Resistor MO	1/4W	5%	220	1	
13	20-2331	Resistor MO	1/4W	5%	330	1	
14	20-2681	Resistor MO	1/4W	5%	680	4	
15							
16							
17							
18	21-1545	Capacitor Cer	18v	-25% +50%	0.010	1	
19	21-1547	Capacitor Cer	18v	-25% +50%	0.033	7	
20							
21							
22							
23	22-0000	Diode GE				20	
24							
25							
26	22-5000	Transistor GE				12	
27	22-5001	Transistor GE				8	

* To be issued later

TABLE AA-12

COMPONENTS LIST

SHIFT REGISTER P.C.B. ASSEMBLY 19-0006

(A.F.C.6)

Cct Ref	Parts List Reference		Physical * Location		Cct. Ref.	Parts List Reference		Physical * Location	
	Item	Table	Grid	Fig.		Item	Table	Grid	Fig.
Resistors Fixed									
R1	8	AA-11			R42	8	AA-11		
R2	5	AA-11			R43	8	AA-11		
R3	4	AA-11			R44	5	AA-11		
R4	9	AA-11			R45	9	AA-11		
R5	10	AA-11			R46	10	AA-11		
R6	5	AA-11			R47	6	AA-11		
R7	6	AA-11			R48	7	AA-11		
R8	4	AA-11			R49	8	AA-11		
R9	7	AA-11			R50	5	AA-11		
R10	8	AA-11			R51	5	AA-11		
R11	11	AA-11							
R12	12	AA-11							
R13	8	AA-11			Capacitors				
R14	5	AA-11			C1	19	AA-11		
R15	9	AA-11			C2	18	AA-11		
R16	10	AA-11			C3	19	AA-11		
R17	4	AA-11			C4	19	AA-11		
R18	6	AA-11			C5	19	AA-11		
R19	7	AA-11			C6	19	AA-11		
R20	8	AA-11			C7	19	AA-11		
R21	13	AA-11			C8	19	AA-11		
R22	8	AA-11							
R23	5	AA-11							
R24	9	AA-11			Diodes				
R25	10	AA-11			D1	23	AA-11		
R26	4	AA-11			D2	23	AA-11		
R27	7	AA-11			D3	23	AA-11		
R28	8	AA-11			D4	23	AA-11		
R29	8	AA-11			D6	23	AA-11		
R30	5	AA-11			D7	23	AA-11		
R31	9	AA-11			D8	23	AA-11		
R32	10	AA-11			D9	23	AA-11		
R33	6	AA-11			D10	23	AA-11		
R34	7	AA-11			D11	23	AA-11		
R35	8	AA-11			D12	23	AA-11		
R36	8	AA-11			D13	23	AA-11		
R37	5	AA-11			D14	23	AA-11		
R38	9	AA-11			D15	23	AA-11		
R39	10	AA-11			D16	23	AA-11		
R40	6	AA-11			D17	23	AA-11		
R41	7	AA-11			D18	23	AA-11		

* To be issued later

Cct. Ref.	Parts List Reference		Physical * Location		Cct. Ref.	Parts List Reference		Physical * Location	
	Item	Table	Grid	Fig.		Item	Table	Grid	Fig.
Diodes Cont'd.									
C19	23	AA-11			Q8	26	AA-11		
C20	23	AA-11			Q9	27	AA-11		
					Q10	26	AA-11		
					Q11	26	AA-11		
					Q12	26	AA-11		
Transistors					Q13	27	AA-11		
Q1	26	AA-11			Q14	26	AA-11		
Q2	27	AA-11			Q15	26	AA-11		
Q3	26	AA-11			Q16	27	AA-11		
Q4	27	AA-11			Q17	26	AA-11		
Q5	27	AA-11			Q18	26	AA-11		
Q6	26	AA-11			Q19	27	AA-11		
Q7	27	AA-11			Q20	26	AA-11		

* To be issued later

TABLE AA-13

PART LIST

CONTROL P.C.B. ASSEMBLY 19-0007

(A.F.C.7)

Item No.	Part No.	Description	Qty.	Vendor *
1	18-0007	Board P.C.	1	
2				
3				
4				
5	20-0102	Resistor Comp 1/10W 10% 1K	1	
6	20-0103	Resistor Comp 1/10W 10% 10K	6	
7	20-0123	Resistor Comp 1/10W 10% 12K	1	
8	20-0152	Resistor Comp 1/10W 10% 1.5K	2	
9	20-0153	Resistor Comp 1/10W 10% 15K	1	
10	20-0183	Resistor Comp 1/10W 10% 18K	1	
11	20-0222	Resistor Comp 1/10W 10% 2.2K	5	
12	20-0332	Resistor Comp 1/10W 10% 3.3K	1	
13	20-0333	Resistor Comp 1/10W 10% 33K	2	
14	20-0471	Resistor Comp 1/10W 10% 470	1	
15	20-0473	Resistor Comp 1/10W 10% 47K	6	
16	20-0562	Resistor Comp 1/10W 10% 5.6K	5	
17	20-0563	Resistor Comp 1/10W 10% 56K	2	
18	20-0683	Resistor Comp 1/10W 10% 68K	1	
19	20-0822	Resistor Comp 1/10W 10% 8.2K	3	
20	20-2100	Resistor MO 1/4W 5% 10	1	
21	20-2123	Resistor MO 1/4W 5% 12K	1	
22	20-2152	Resistor MO 1/4W 5% 1.5K	1	
23	20-2182	Resistor MO 1/4W 5% 1.8K	1	
24	20-2221	Resistor MO 1/4W 5% 220	1	
25	20-2222	Resistor MO 1/4W 5% 2.2K	2	
26	20-2273	Resistor MO 1/4W 5% 27K	2	
27	20-2471	Resistor MO 1/4W 5% 470	1	
28	20-2681	Resistor MO 1/4W 5% 680	1	
29	20-2682	Resistor MO 1/4W 5% 6.8K	2	
30	20-2822	Resistor MO 1/4W 5% 8.2K	1	
31	20-3100	Resistor MO 1/2W 5% 10	1	
32	20-3182	Resistor MO 1/2W 5% 1.8K	1	
33	20-3471	Resistor MO 1/2W 5% 470	1	
34				
35				
36				
37	20-6511	Resistor Var 10% 2.2K	1	
38	20-6512	Resistor Var 20% 4.7K	1	

* To be issued later

Item No.	Part No.	Description				Qty.	Vendor *
39							
40							
41							
42	21-0500	Capacitor Elytic	25V	-20% +100%	10	1	
43	21-0502	Capacitor Elytic	25V	-20% +100%	50	1	
44	21-1524	Capacitor Cer	500V	10%	220p	3	
45	21-1532	Capacitor Cer	500V	10%	1Kp	4	
46	21-1545	Capacitor Cer	18V	10%	0.01	1	
47	21-1547	Capacitor Cer	18V	10%	0.033	2	
48	21-4506	Capacitor Plstr.	100V	10%	0.1	6	
49	21-4510	Capacitor Plstr.	60V	10%	0.47	2	
50	21-4512	Capacitor Plstr.	60V	10%	1	1	
51	21-4505	Capacitor Plstr.	250V	10%	0.068	1	
52							
53							
54	22-0000	Diode GE				7	
55	22-1000	Diode Si				1	
56	22-~~1000~~ 1810	Diode Si				1	
57							
58							
59							
60							
61	22-5000	Transistor GE				13	
62	22-5001	Transistor GE				3	
63	22-6000	Transistor Si				1	

* To be issued later.

TABLE AA-14

COMPONENTS LIST

CONTROL P.C.B. ASSEMBLY 19-0007

(A.F.C.7)

Cct. Ref.	Parts List Reference		Physical* Location		Cct. Ref.	Parts List Reference		Physical * Location	
	Item	Table	Grids	Fig.		Item	Table	Grids	Fig.
Resistors Fixed									
R1	6	AA-13			R41	19	AA-13		
R2	26	AA-13			R42	33	AA-13		
R3	26	AA-13			R43	20	AA-13		
R4	25	AA-13			R44	15	AA-13		
R5	27	AA-13			R45	6	AA-13		
R6	23	AA-13			R46	8	AA-13		
R7	29	AA-13			R47	15	AA-13		
R8	25	AA-13			R48	16	AA-13		
R9	29	AA-13			R49	16	AA-13		
R10	7	AA-13			R50	16	AA-13		
R11	30	AA-13			R51	22	AA-13		
R12	21	AA-13			R52	16	AA-13		
R13	15	AA-13			R53	18	AA-13		
R14	12	AA-13			R54	32	AA-13		
R15	17	AA-13			R55	11	AA-13		
R16	8	AA-13							
R17	11	AA-13			Capacitors				
R18	14	AA-13			C1	51	AA-13		
R19	11	AA-13			C2	44	AA-13		
R20	17	AA-13			C3	50	AA-13		
R21	16	AA-13			C4	49	AA-13		
R22	9	AA-13			C5	46	AA-13		
R23	15	AA-13			C6	44	AA-13		
R24	11	AA-13			C7	44	AA-13		
R25	6	AA-13			C8	48	AA-13		
R26	6	AA-13			C9	45	AA-13		
R27	11	AA-13			C10	45	AA-13		
R28	15	AA-13			C11	45	AA-13		
R29	13	AA-13			C12	45	AA-13		
R30	6	AA-13			C13	43	AA-13		
R31	10	AA-13			C14	48	AA-13		
R32	28	AA-13			C15	42	AA-13		
R33	24	AA-13			C16	41	AA-13		
R34	19	AA-13			C17	48	AA-13		
R35	19	AA-13			C18	47	AA-13		
R36	31	AA-13			C19	48	AA-13		
R37	13	AA-13			C20	47	AA-13		
R38	6	AA-13			C21	49	AA-13		
R39	5	AA-13							
R40	15	AA-13							

* To be issued later

Cct. Ref.	Parts List Reference		Physical * Location		Cct. Ref,	Parts List Reference		Physical * Location	
	Item	Table	Grids	Fig.		Item	Table	Grids	Fig.
Resistors					Transistors				
Variable					Q1	61	AA-13		
RV1	37	AA-13			Q2	61	AA-13		
RV2	38	AA-13			Q3	61	AA-13		
					Q4	63	AA-13		
Diodes					Q5	61	AA-13		
D1	55	AA-13			Q6	61	AA-13		
D2	54	AA-13			Q7	61	AA-13		
D3	54	AA-13			Q8	61	AA-13		
D4	54	AA-13			Q9	61	AA-13		
D5	54	AA-13			Q10	61	AA-13		
D6	54	AA-13			Q11	62	AA-13		
D7	54	AA-13			Q12	61	AA-13		
D8	54	AA-13			Q13	61	AA-13		
D9	56	AA-13			Q14	62	AA-13		
					Q15	61	AA-13		
					Q16	61	AA-13		
					Q17	62	AA-13		

* To be issued later

TABLE AA-15

PARTS LIST

INTER-CONNECTING P.C.B. ASSEMBLY 19-0008
(A.F.C.8)

Item No.	Part No.	Description	Qty.	Vendor *
1	18-0008	Board P.C.	1	
2				
3				
4				
5				
6	20-0221	Resistor Comp 1/10W 10% 220	1	
7				
8				
9				
10				
11				
12	23-5010	Edge Connector 20 Way	1	
13	23-5011	Edge Connector 20 Way	2	

* To be issued later

TABLE AA-17

PARTS LIST

500MHz A.F.C. PACKAGE 11-0000

Item No.	Part No.	Description			Qty	Vendor *
1	14-0040	Screw - Hexl.			20	
2	14-0041	Screw - Retention Hexl.			3	
3	14-0042	Spacer - Hexl.			3	
4						
5						
6	15-0017	Spacer - Tappex			20	
7						
8						
9						
10	16-0021	Casting Machining			1	
11						
12						
13						
14	19-0001	A.F.C.1 Multiplier			1	
15	19-0002	A.F.C.2 Harmonic Selector			1	
16	19-0003	A.F.C.3 Mixer			1	
17	19-0004	A.F.C.4 Amplifier			1	
18	19-0005	A.F.C.5 Filter			1	
19	19-0006	A.F.C.6 Shift Register			1	
20	19-0007	A.F.C.7 Control			1	
21	19-0008	A.F.C.8 Inter Connecting			1	
22						
23						
24	21-6500	Capacitor Feed Thru.	+80% -20%	1kp	18	
25						
26						
27	23-3005	Socket B.N.C.	50Ω		1	
28						
29						
30						

* To be Issued later

TABLE AA-18

COMPONENTS LIST

500MHz A.F.C. ASSEMBLY 11-0000

Cct. Ref.	Parts List Reference Item	Table	Physical * Location Grid	Fig.
Resistors				
R4	6	AA-15		
Capacitors				
C1	24	AA-17		
C2	24	AA-17		
C3	24	AA-17		
C4	24	AA-17		
C5	24	AA-17		
C6	24	AA-17		
C7	24	AA-17		
C8	24	AA-17		
C9	24	AA-17		
C10	24	AA-17		
C11	24	AA-17		
C12	24	AA-17		
C13	24	AA-17		
C14	24	AA-17		
C15	24	AA-17		
C16	24	AA-17		
C17	24	AA-17		
C18	24	AA-17		
Sockets				
SKTA	27	AA-17		

* To be issued later

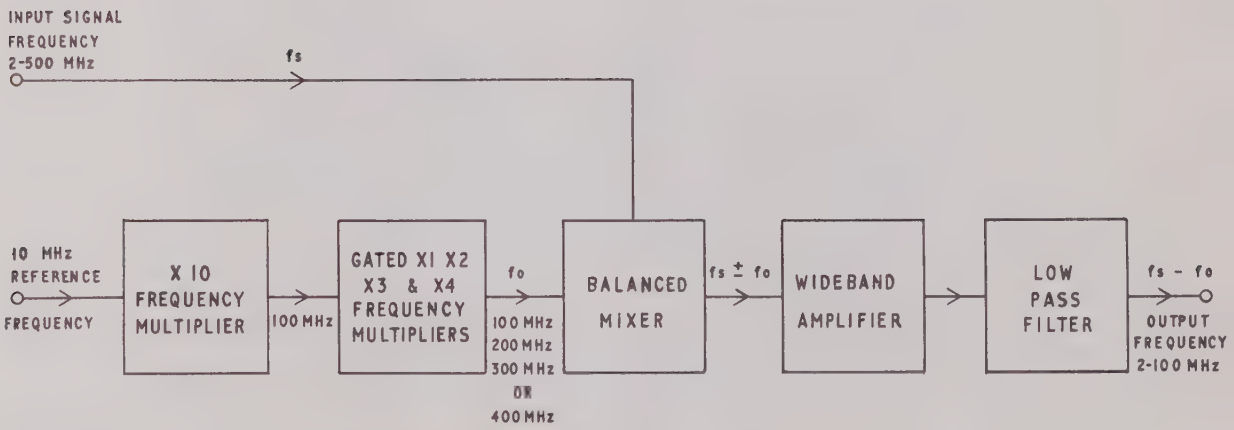


Fig. AA-1 Simplified functional diagram

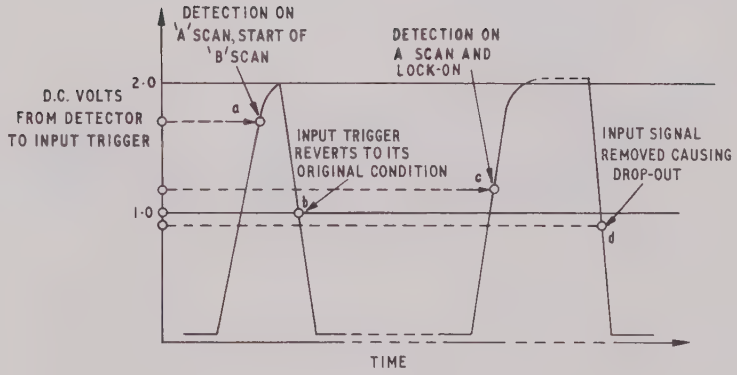
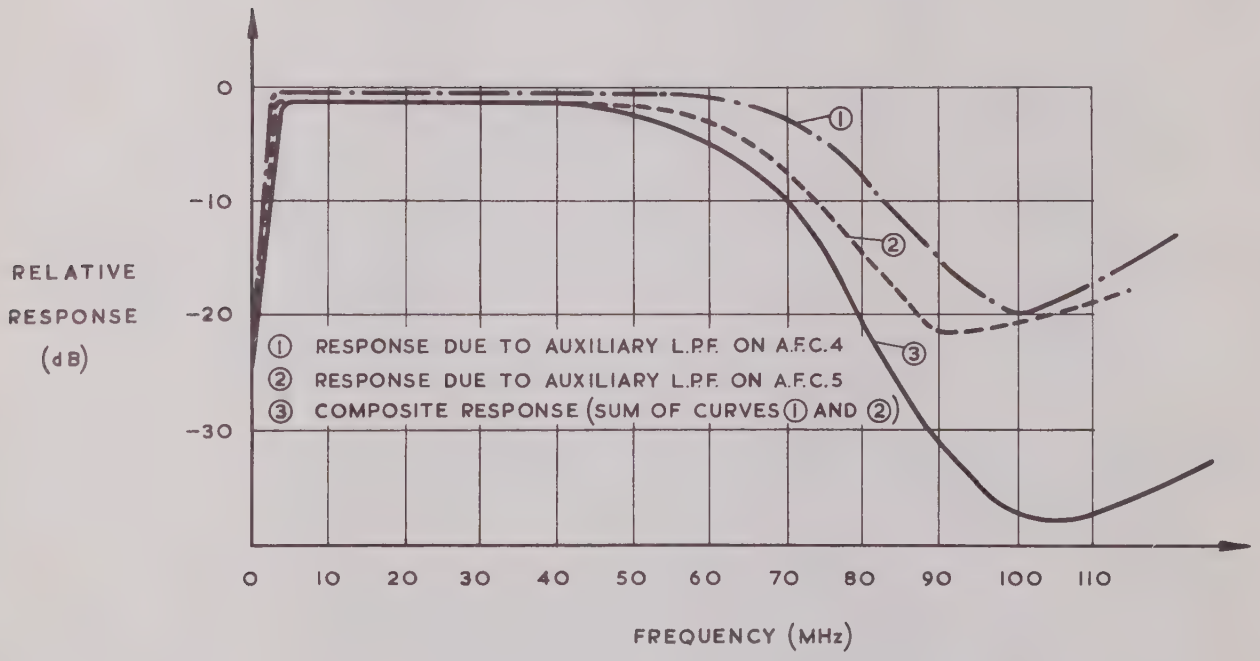
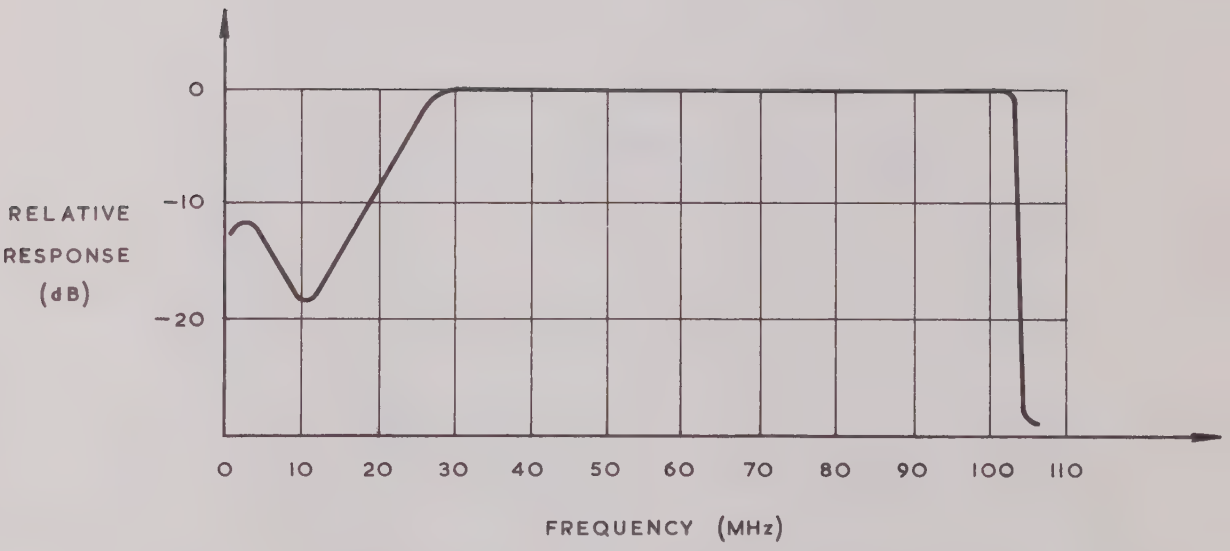


Fig. AA-2 Input Trigger Characteristics



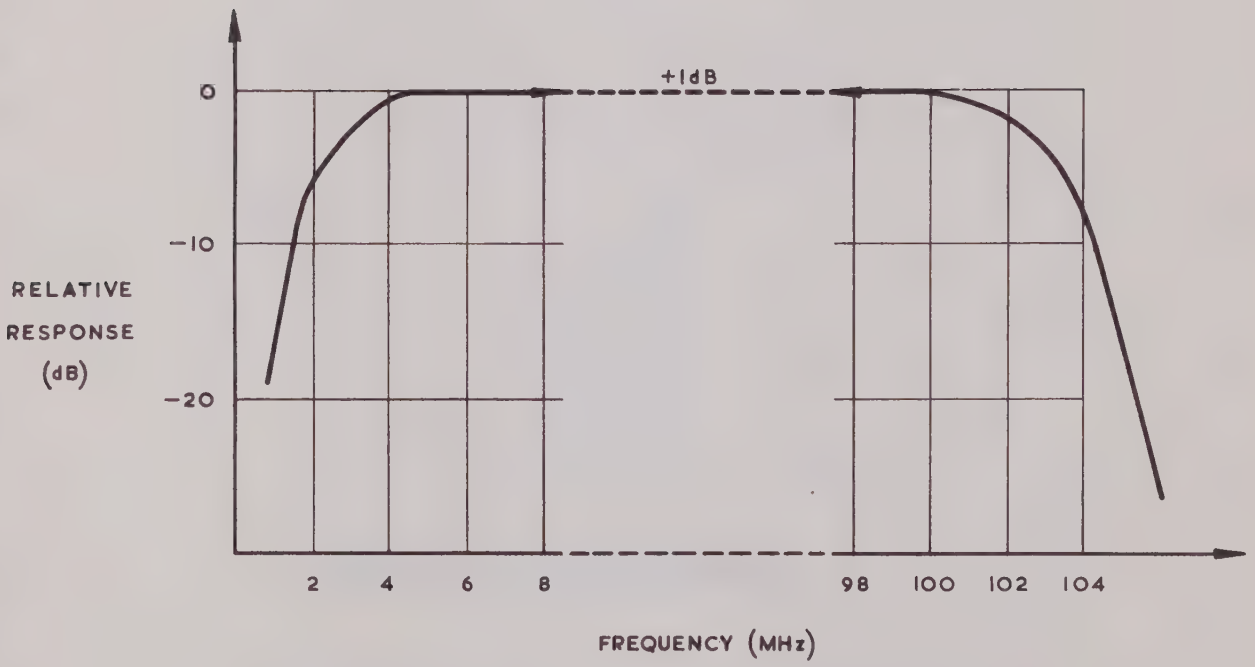
IDEALISED RESPONSE OF A.F.C. ASSEMBLY
ON RANGE 1A (102 TO 160 MHz)

FIG. AA-3



IDEALISED RESPONSE OF A.F.C. ASSEMBLY
ON RANGE 1B (160 TO 202 MHz)

FIG. AA-4



IDEALISED RESPONSE OF A.F.C. ASSEMBLY

FIG. AA-5 ON RANGES 0, 2, 3, AND 4

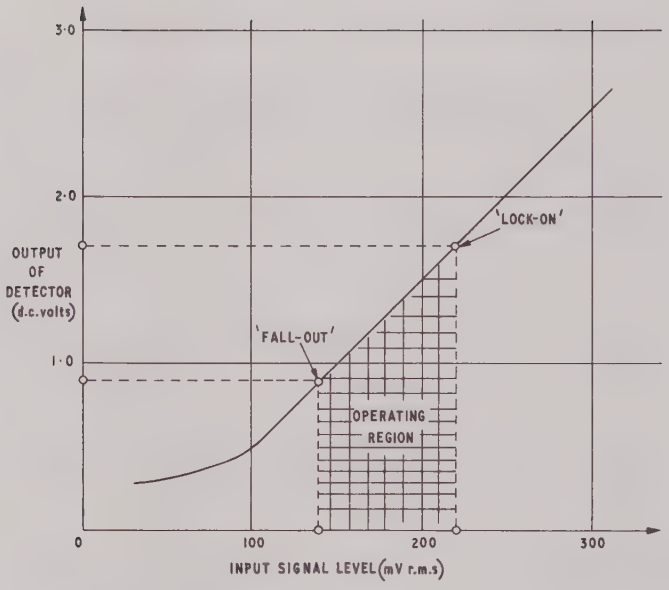
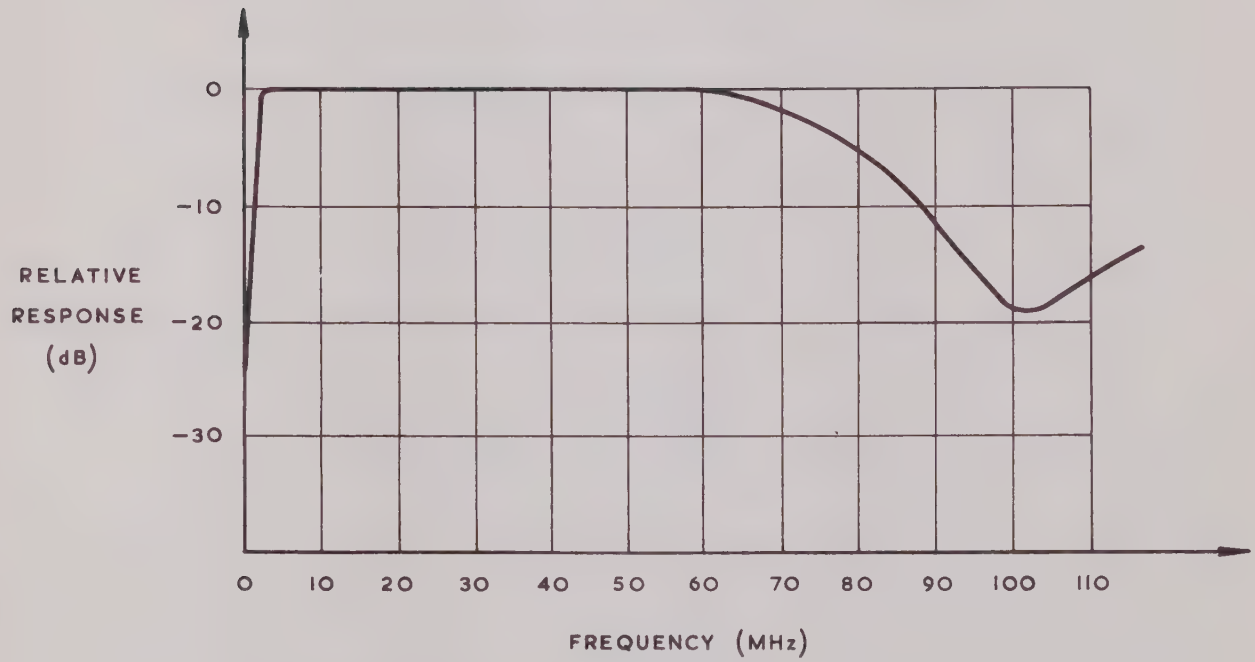


Fig.AA-6 Detector Characteristic



IDEALISED RESPONSE OF AUXILIARY

FIG. AA-7 LOW-PASS FILTER ON A.F.C.4

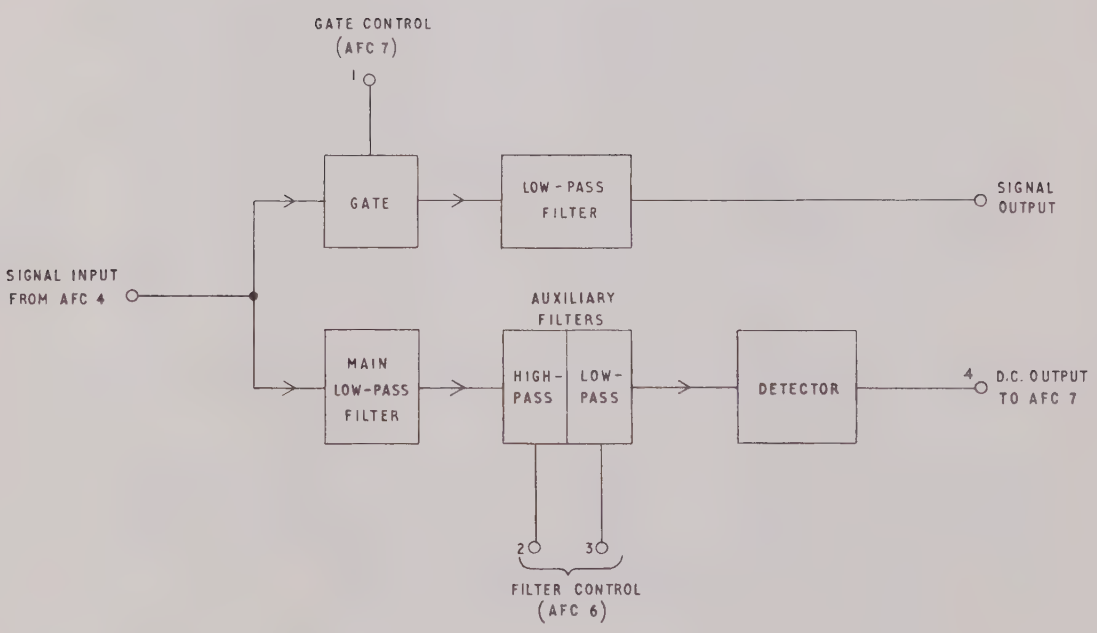
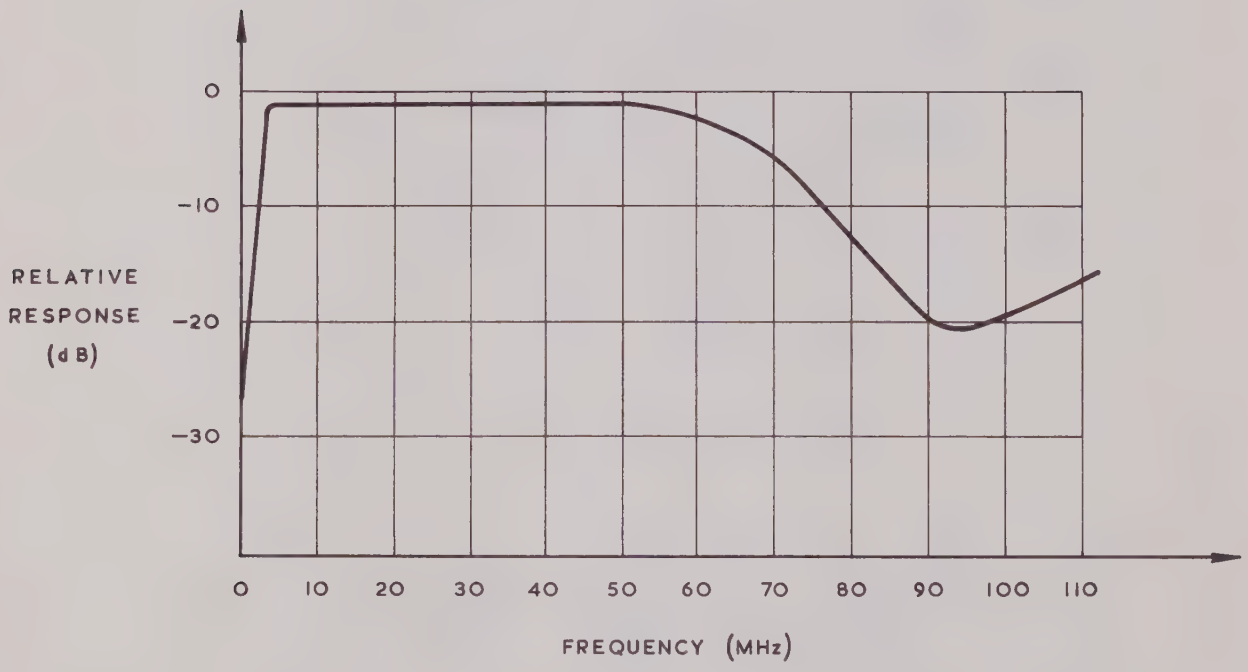
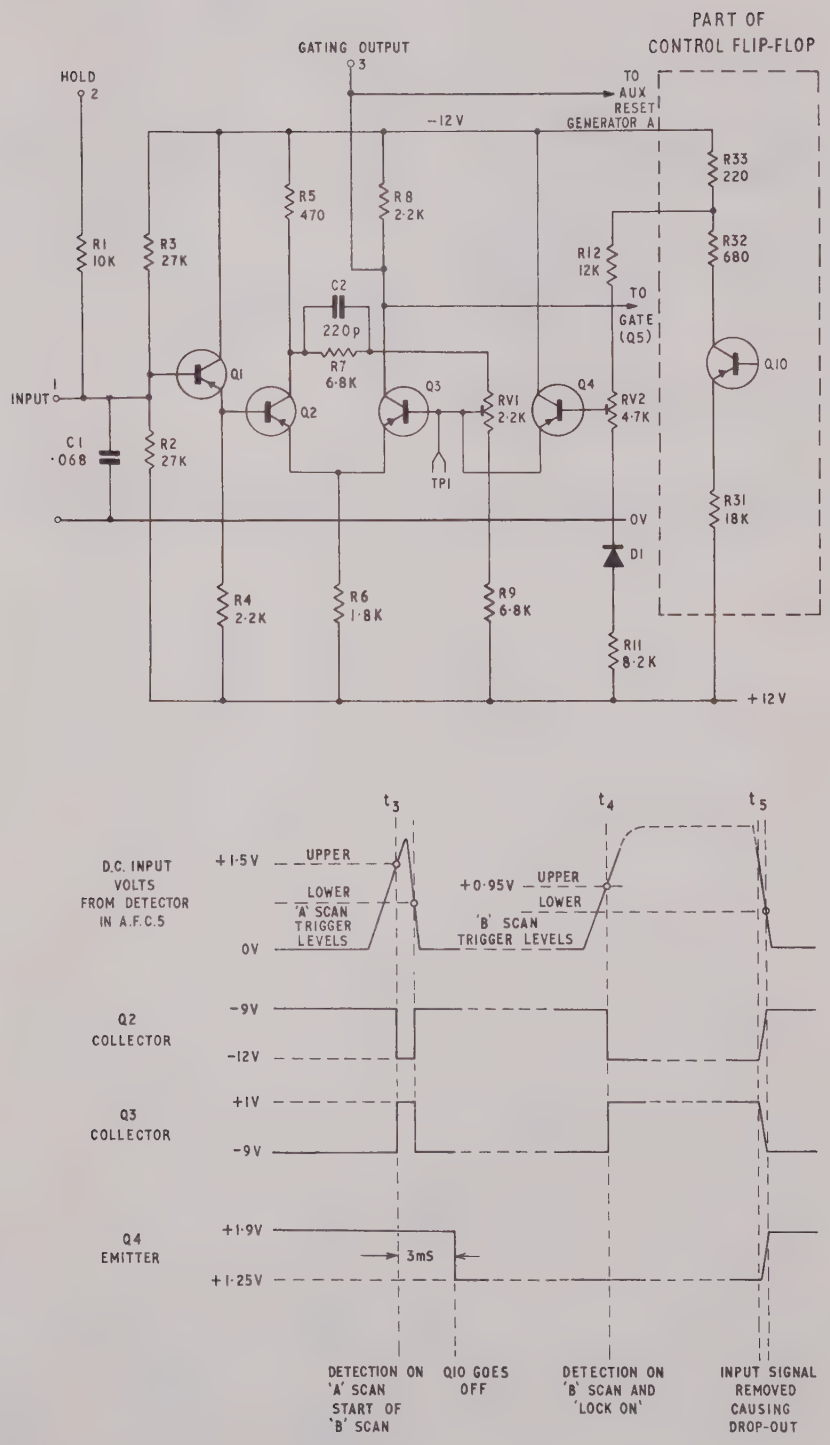


Fig. AA-8 P.C.B. Assembly AFC 5 : Functional Block Diagram



IDEALISED RESPONSE OF AUXILIARY

FIG. AA-9 LOW-PASS FILTER ON A.F.C.5



Input Trigger (A.F.C.7.) Fig. AA-10
Circuit and Waveforms

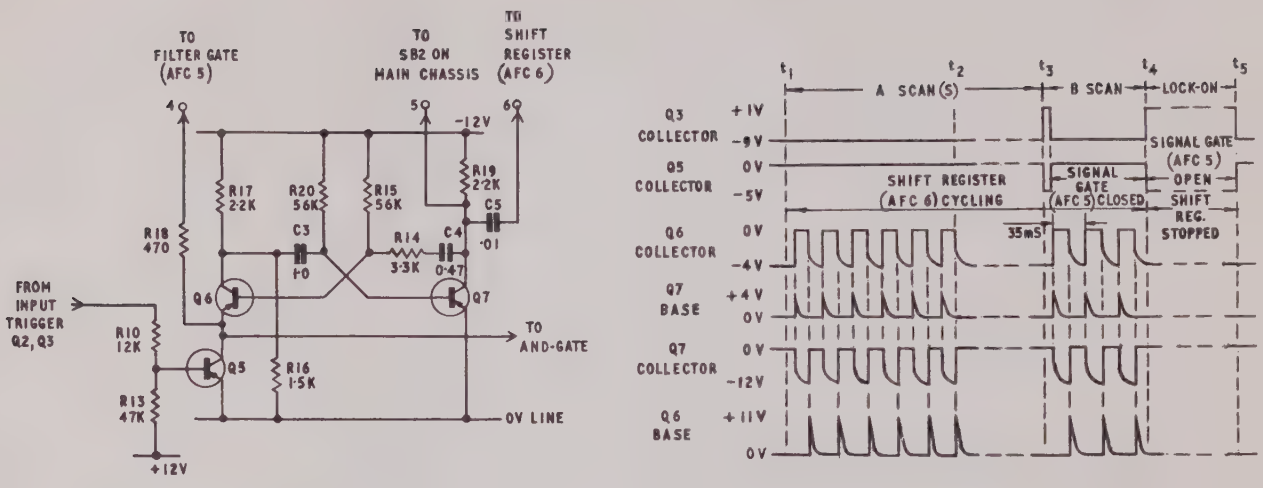


Fig. AA-11 Sequencing Generator (AFC 7): Circuit and Waveforms

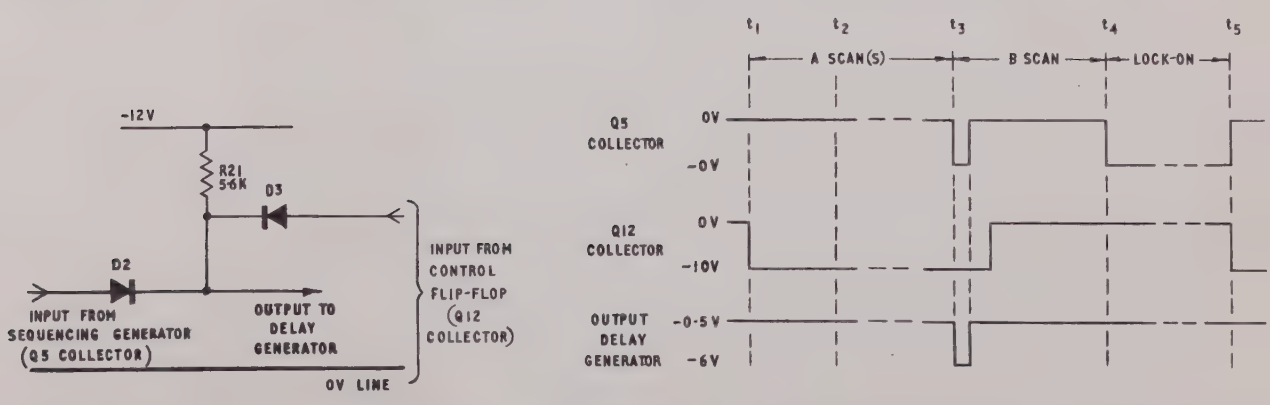


Fig. AA-12 And-gate (AFC 7): Circuit and Waveforms

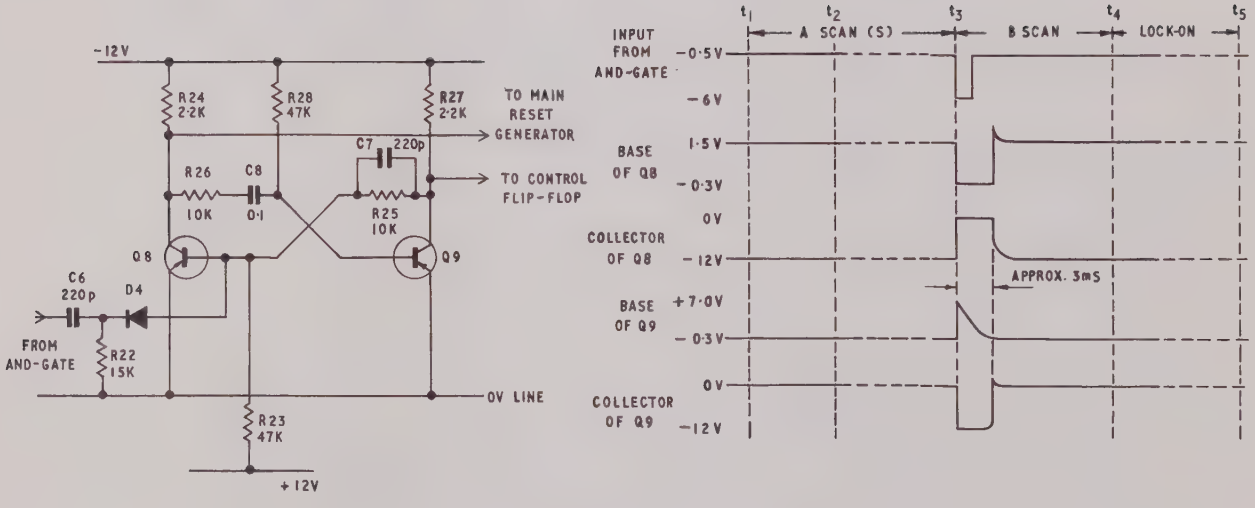
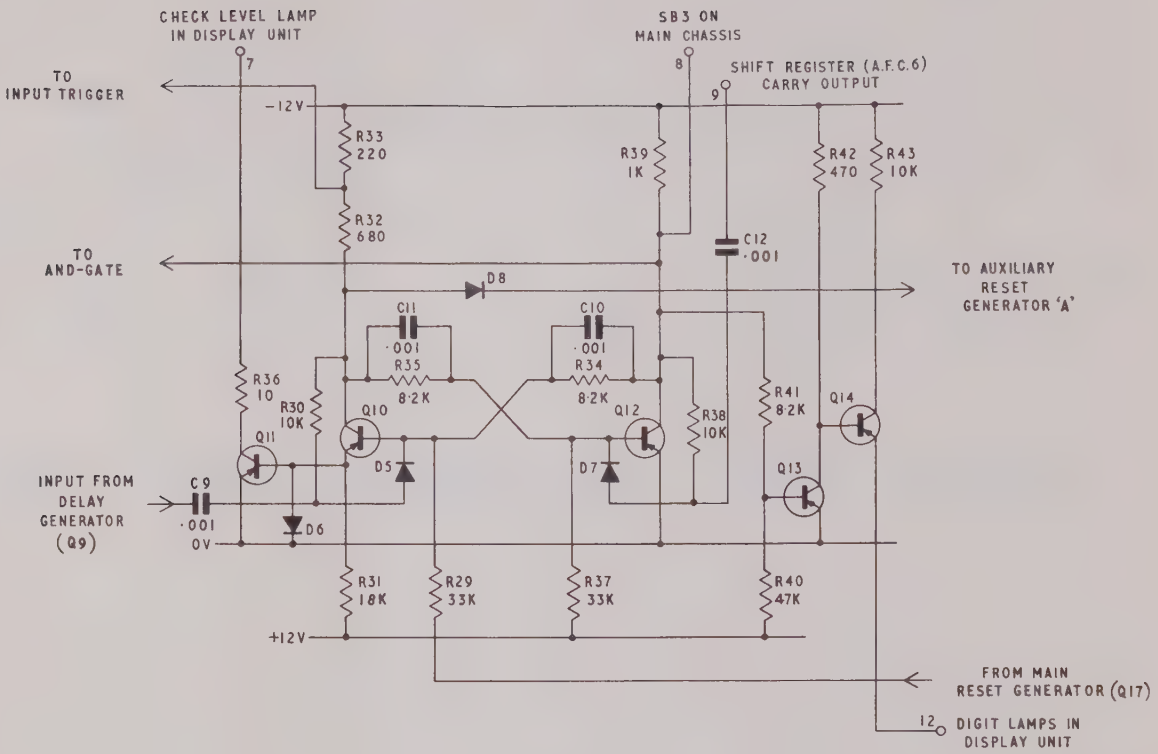


Fig. AA-13 Delay Generator : Circuit and Waveforms.



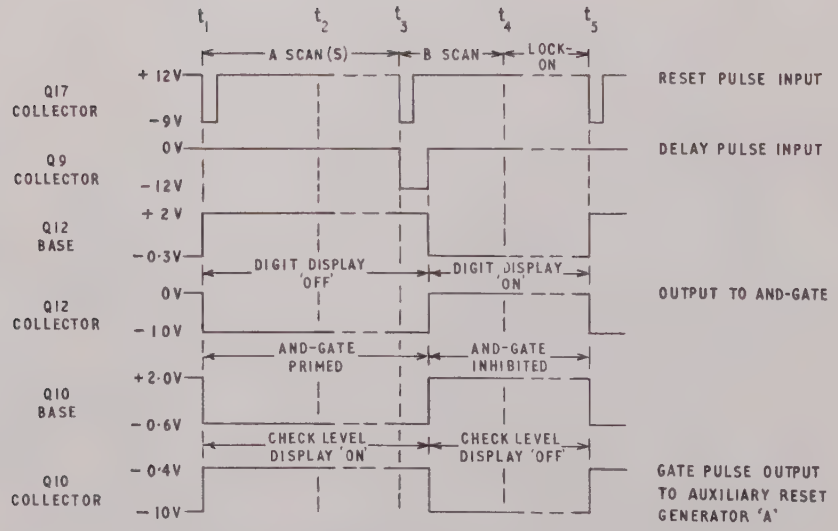


Fig. AA-14 Control Flip-Flop (AFC 7): Circuit and Waveforms

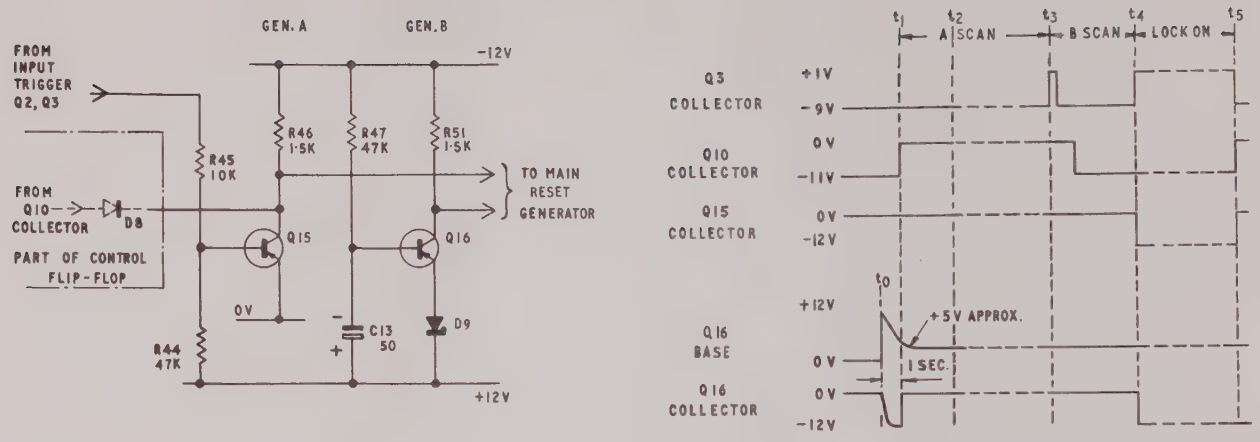


Fig: AA-15 Auxiliary Reset Generators (AFC7): Circuits and Waveforms

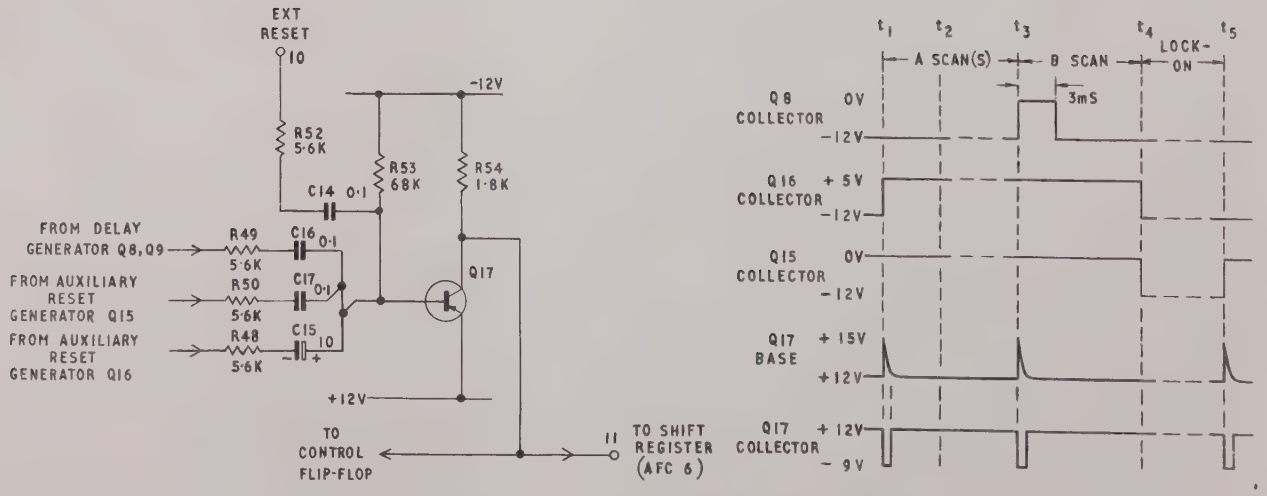
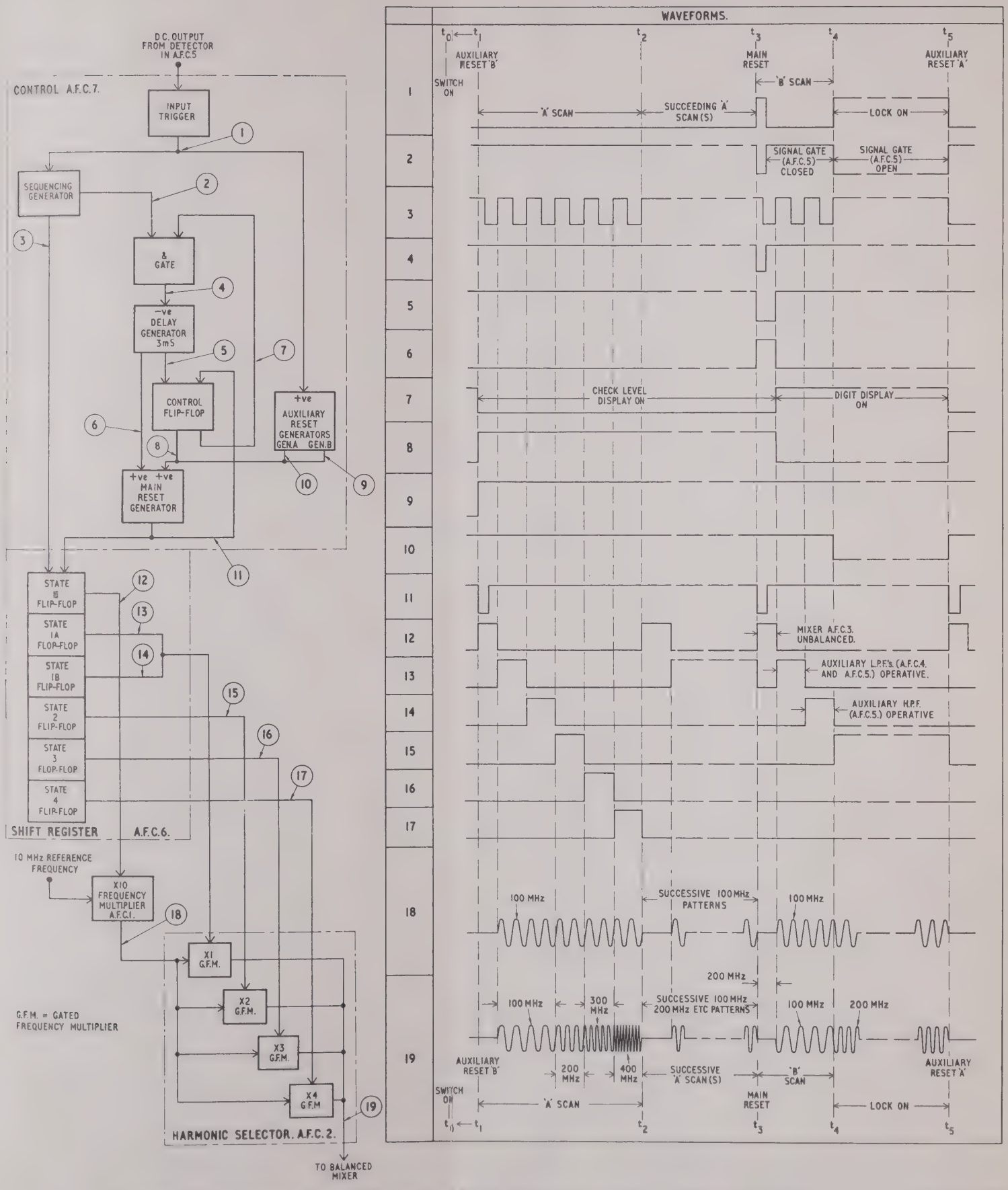


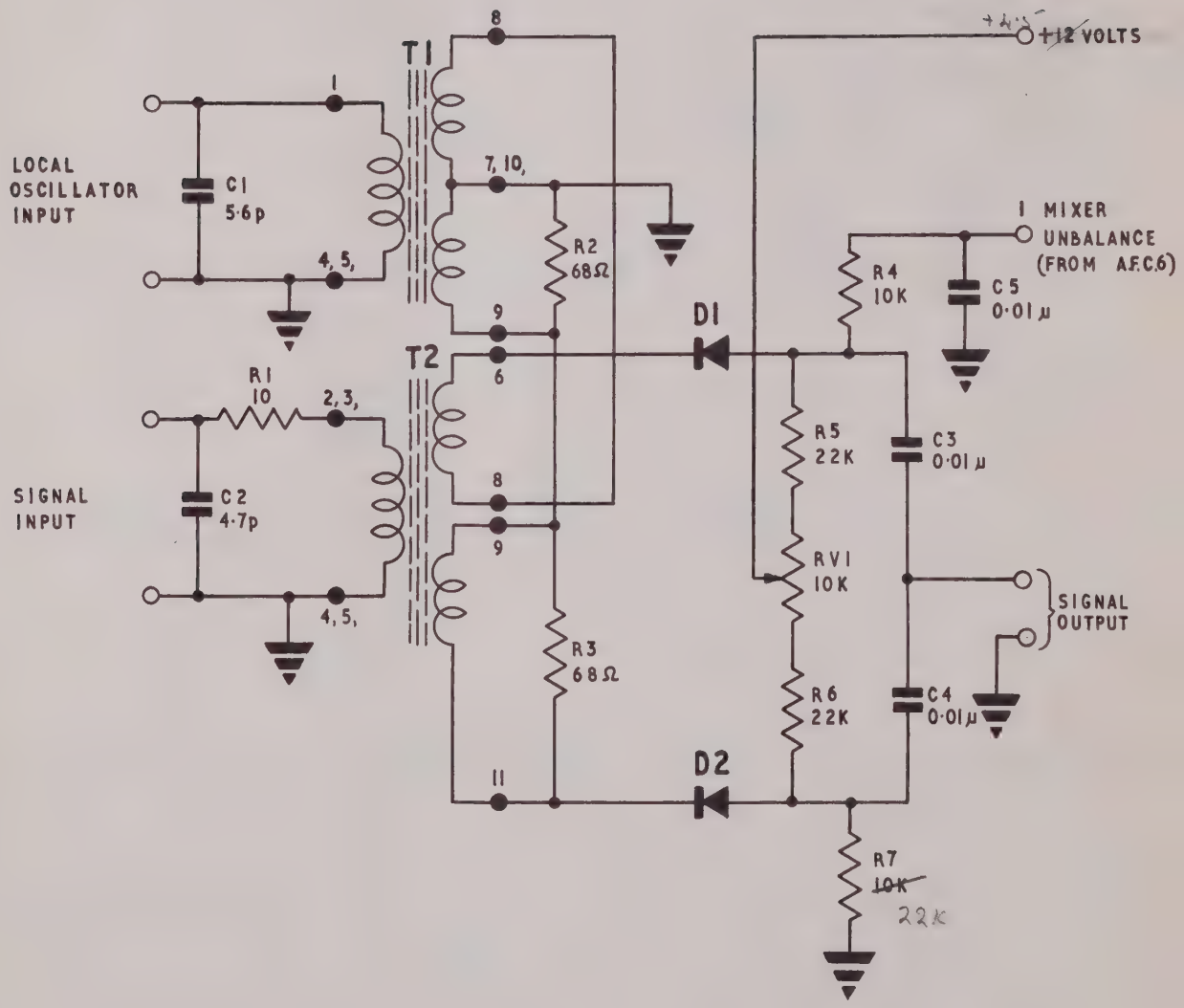
Fig. AA-16 Main Reset Generator (AFC 7): Circuit and Waveforms



Control Sequence Waveforms for 500 MHz A.F.C. Assembly 11-0000.

Fig.AA-17

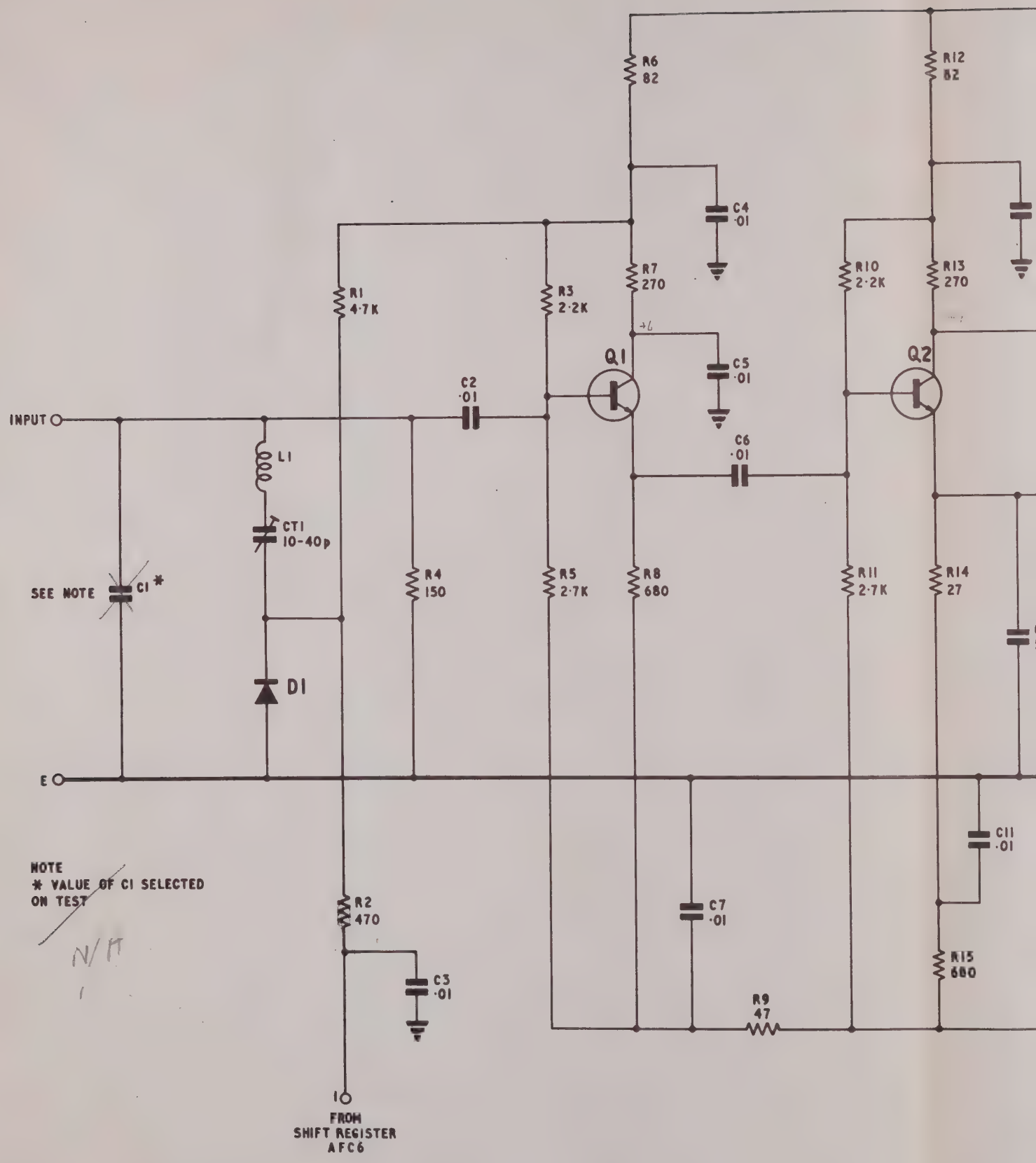
Input Signal Frequency Between 202 and 302 MHz.



19-0003
1

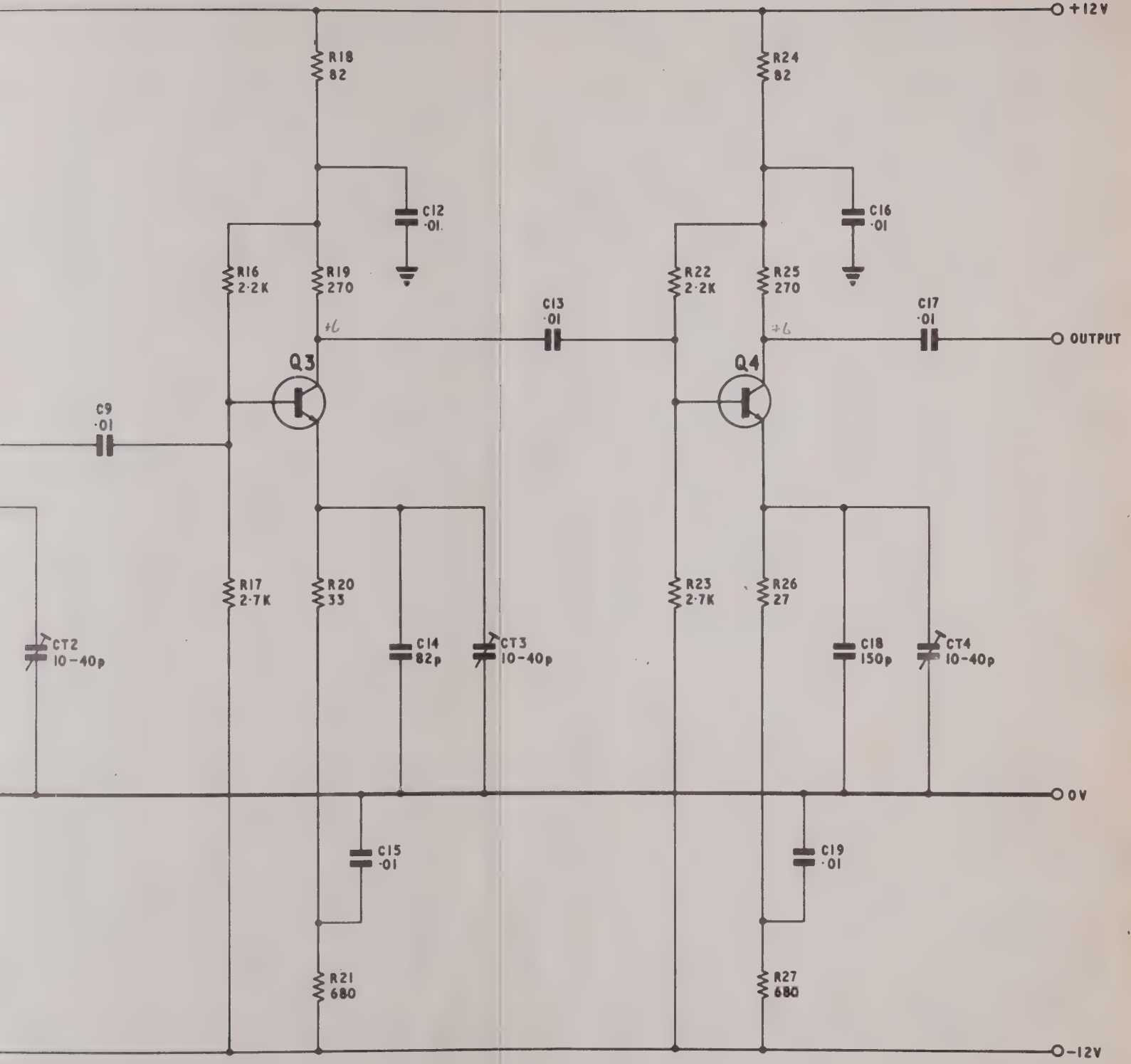
Circuit Balanced Mixer
P.C.B. Assembly 19-0003 (AFC 3)

Fig. AA-23



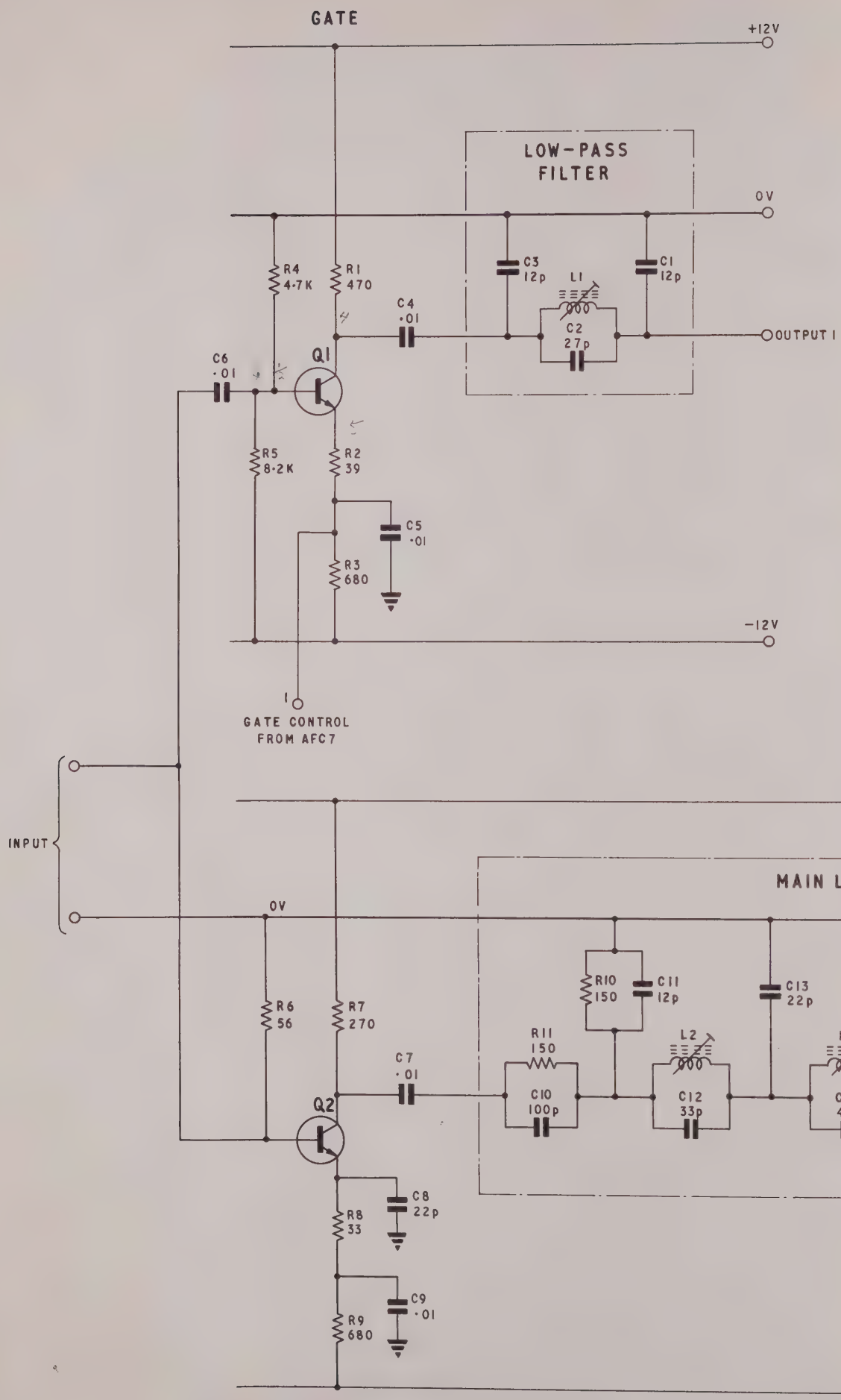
19-0004
1

Circuit : 100 M



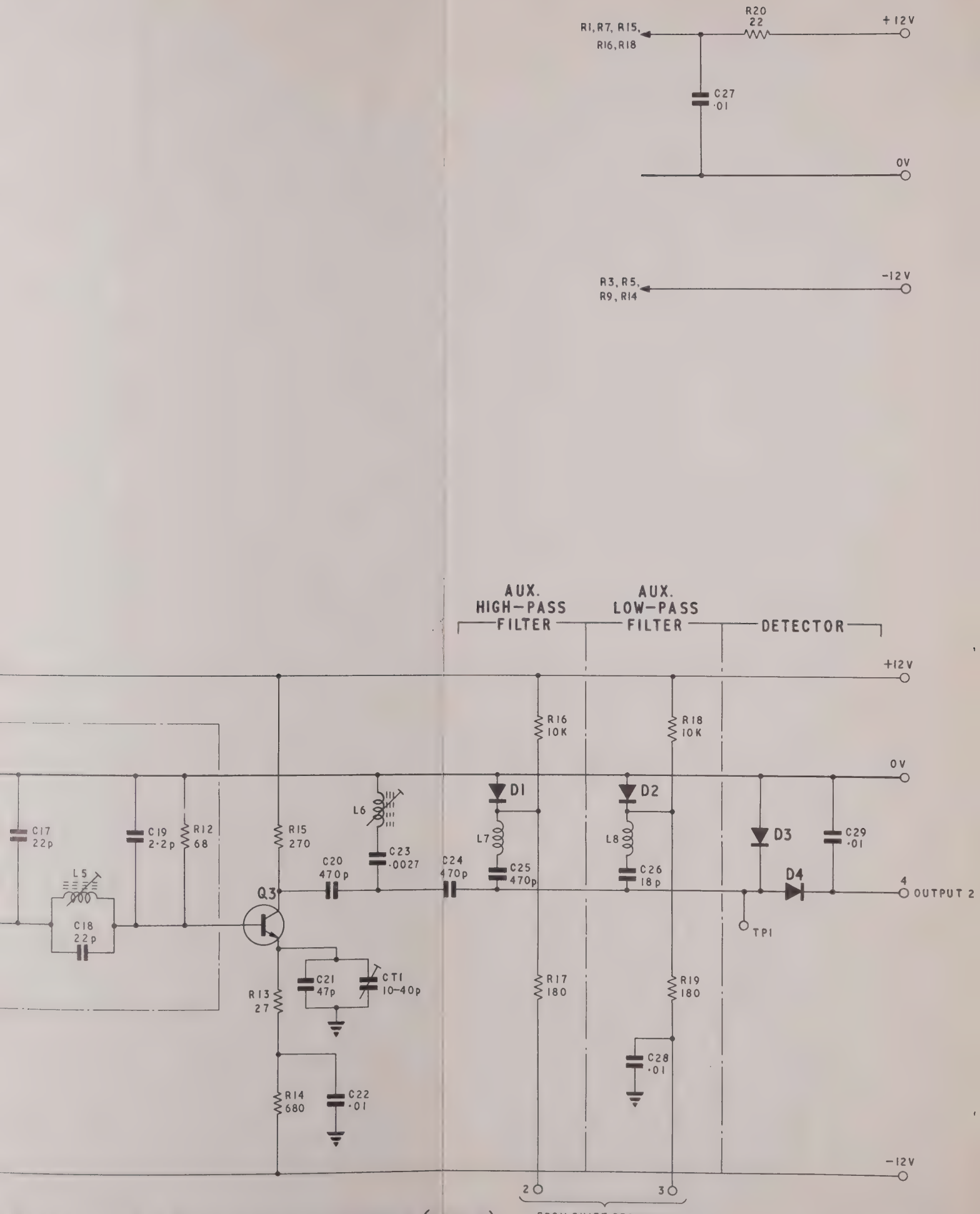
Amplifier P.C.B. Assembly 19-0004 (AFC4)

Fig. AA-25



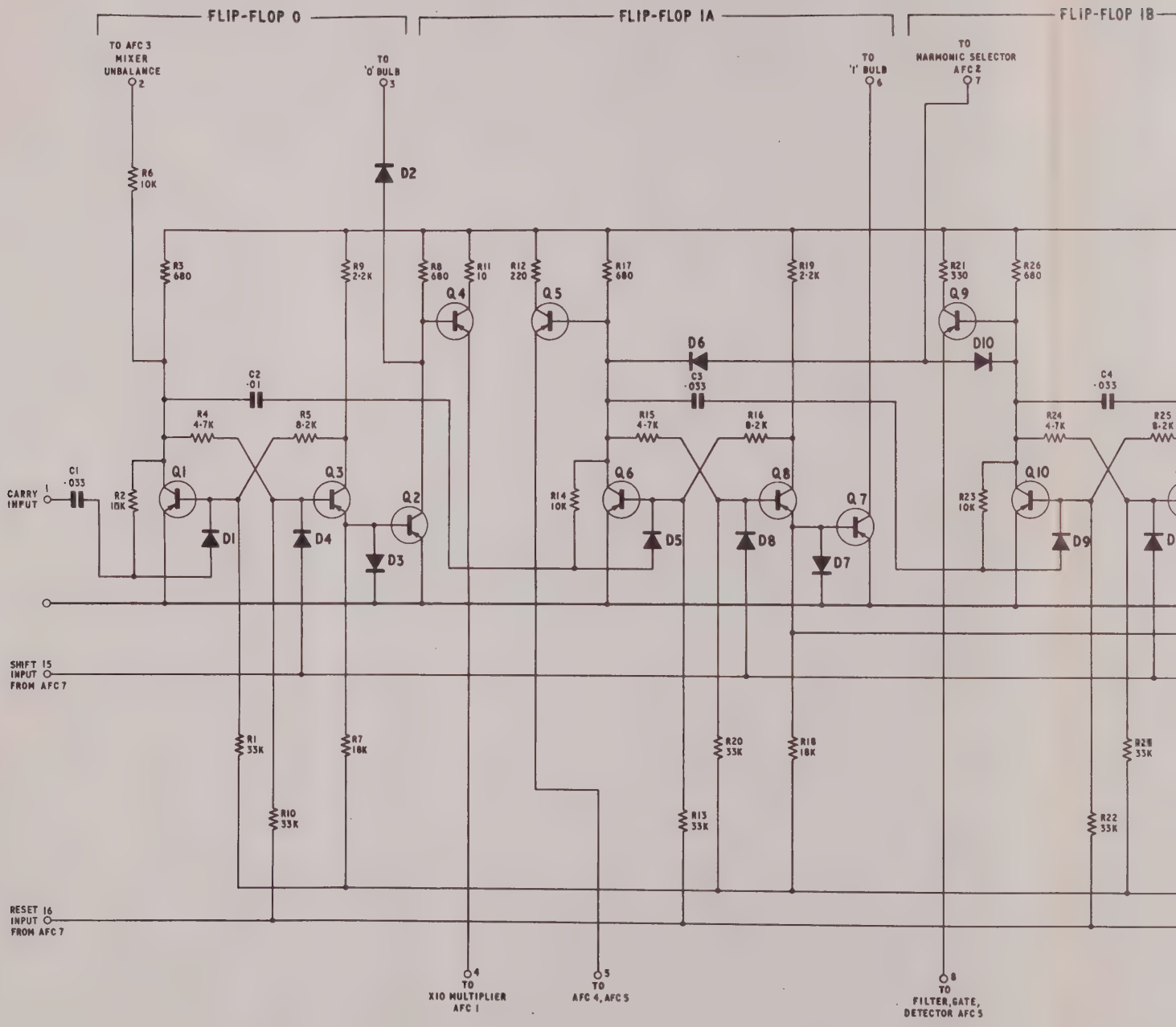
19-0005
1

Circuit : Gate and



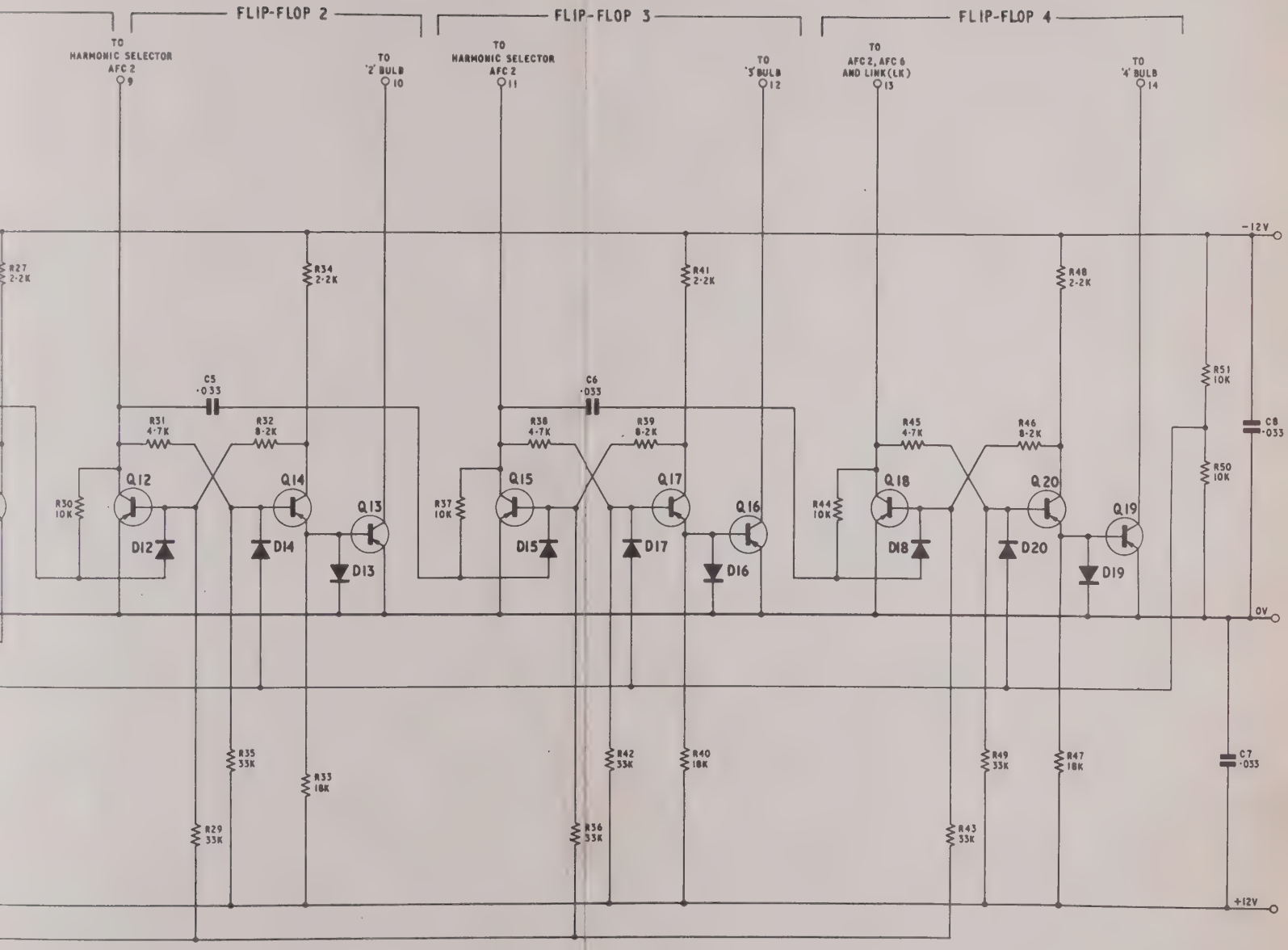
Detector P.C.B. Assembly 19-0005 (AFC 5)

Fig.AA-27



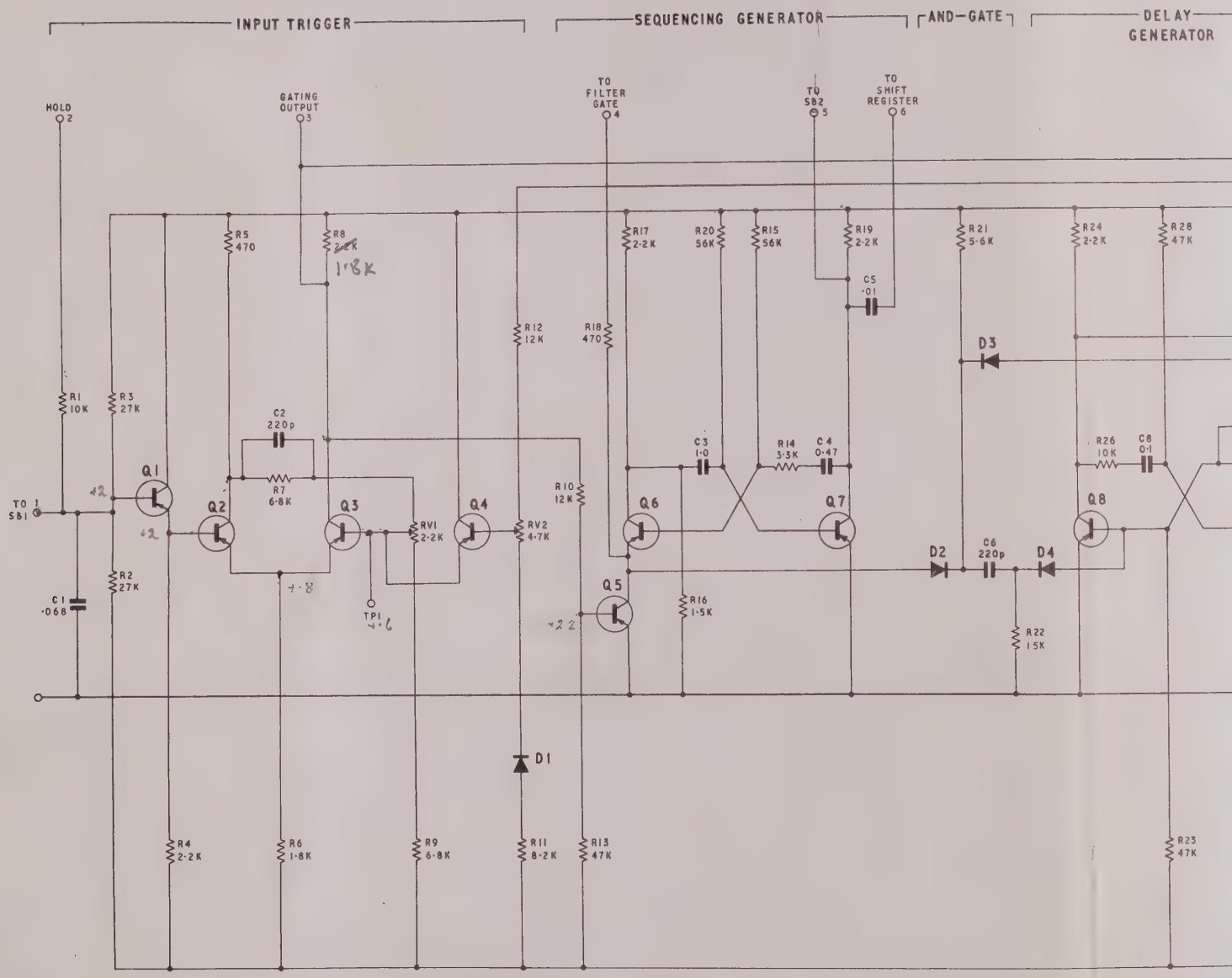
19-0006
1

Circuit :



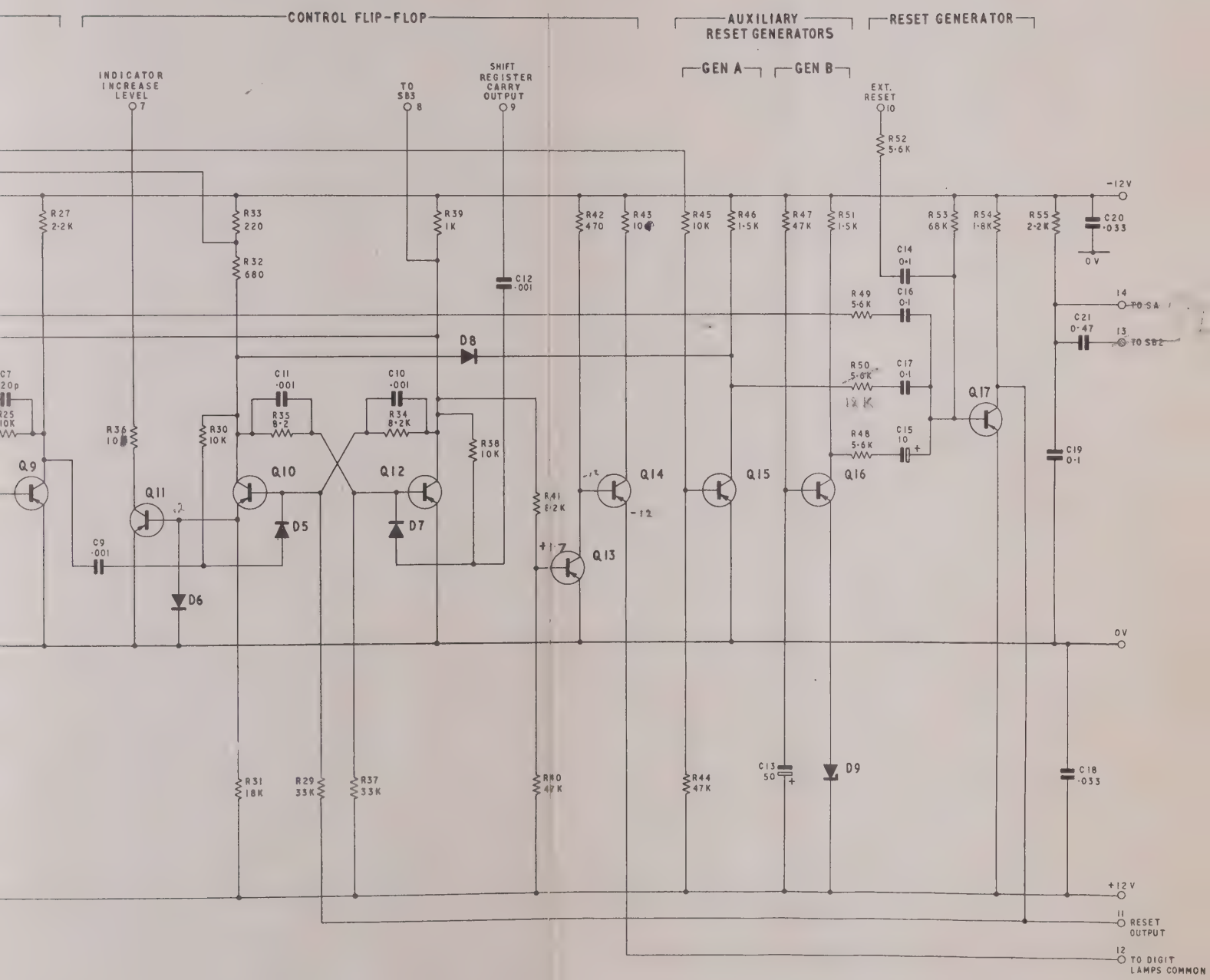
hift Register P.C.B. Assembly 19-0006 (AFC 6)

Fig.AA-29



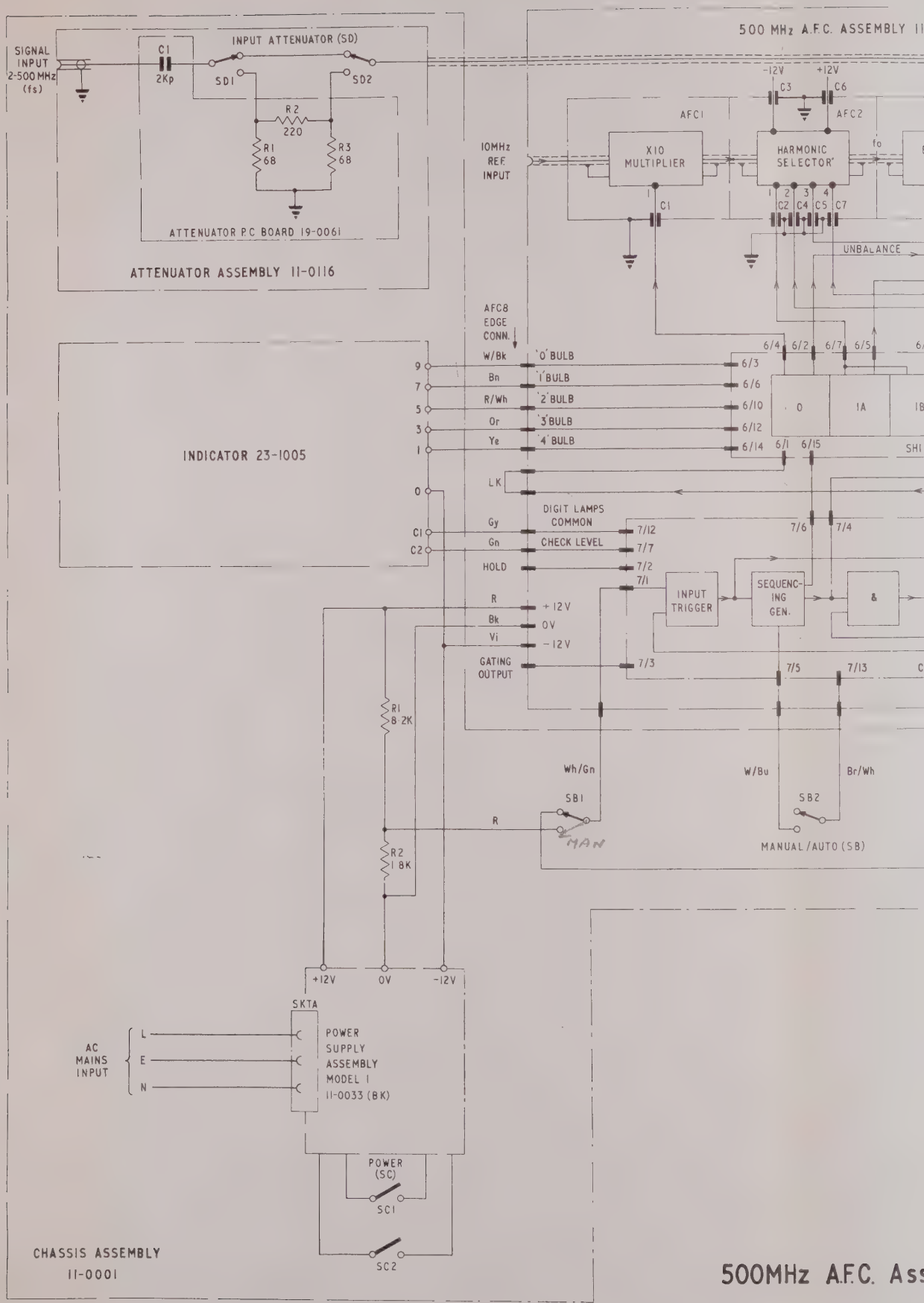
19-0007
1

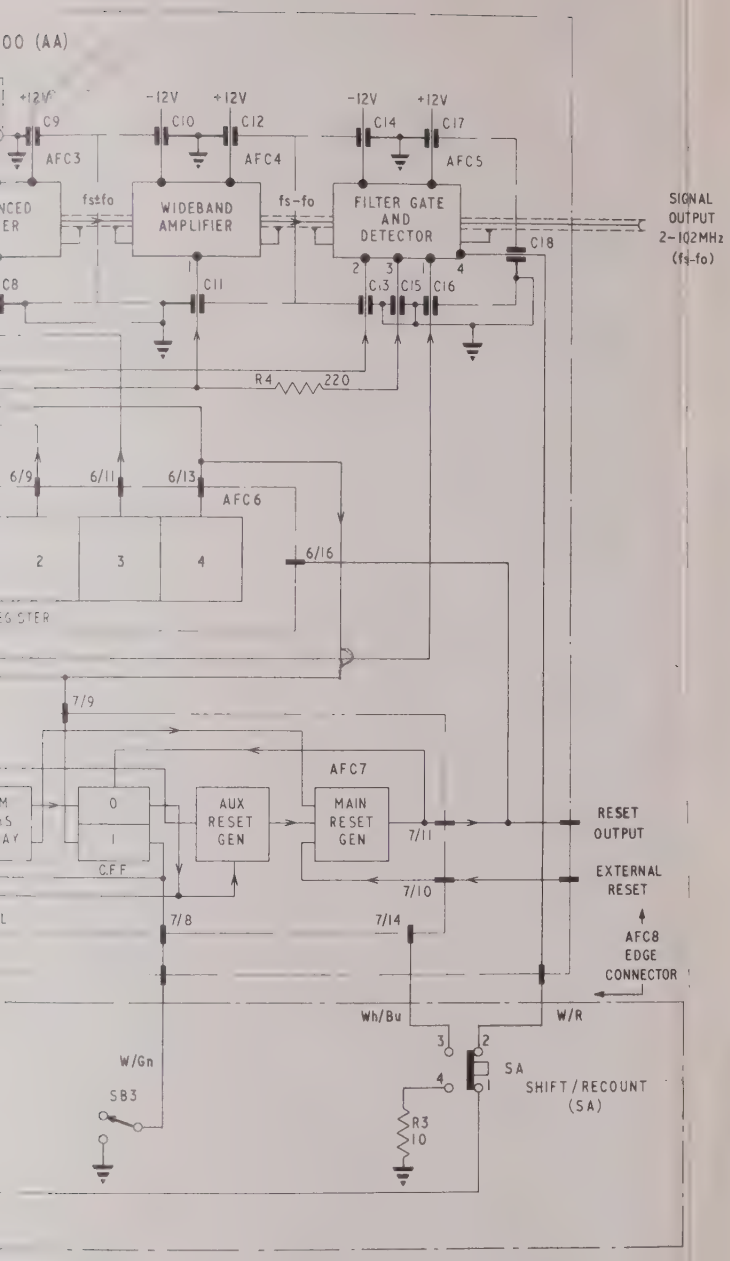
Circuit

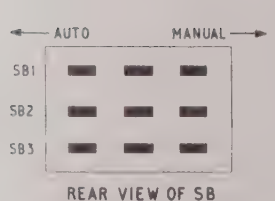


Control P.C.B. Assembly 19-0007 (AFC 7)

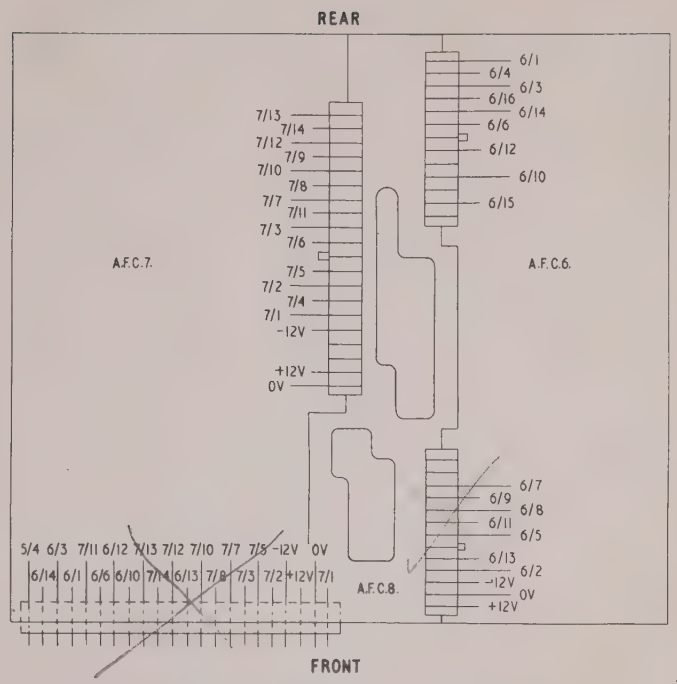
Fig. AA-31


500 MHz A.F.C. ASSEMBLY II
SIGNAL INPUT 2-500 MHz (fs)
C1 2Kp
INPUT ATTENUATOR (SD)
SD1
SD2
R2 220
R1 68
R3 68
ATTENUATOR P.C BOARD 19-0061
ATTENUATOR ASSEMBLY II-0116
10MHz REF. INPUT
X10 MULTIPLIER
HARMONIC SELECTOR
-12V
+12V
C3
C6
AFC1
AFC2
fo
C1
C2
C4
C5
C7
UNBALANCE
AFC8 EDGE CONN.
INDICATOR 23-1005
W/Bk '0' BULB
Bn '1' BULB
R/Wh '2' BULB
Or '3' BULB
Ye '4' BULB
LK
Gy DIGIT LAMPS COMMON
Gn CHECK LEVEL
HOLD
R +12V
Bk 0V
Vi -12V
GATING OUTPUT
INPUT TRIGGER
SEQUENC-ING GEN.
&
R1 8.2K
R2 1.8K
Wh/Gn
W/Bu
Br/Wh
SB1
SB2
MAN
MANUAL/AUTO (SB)
+12V
0V
-12V
SKTA
AC MAINS INPUT
L
E
N
POWER SUPPLY ASSEMBLY MODEL I 11-0033 (BK)
POWER (SC)
SC1
SC2
CHASSIS ASSEMBLY 11-0001
500MHz A.F.C. Ass

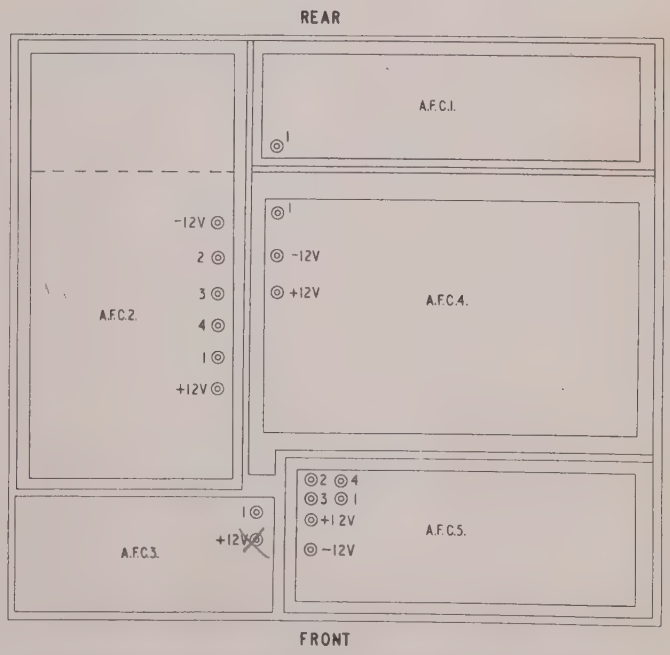




REAR VIEW OF SB



KEY TO EDGE CONNECTORS ON BOARDS AFC6, 7 & 8 OF 500MHz AFC ASSEMBLY 11-0000



KEY TO CONTROL TERMINALS ON BOARDS AFC1 – AFC5 OF 500MHz AFC ASSEMBLY 11-0000

bly 11-0000: Detailed Block Diagram

Fig. AA-35

SECTION BH

TECHNICAL DESCRIPTION

AUXILIARY POWER SUPPLY ASSEMBLY 11-0031

CONTENTS

	Page No.
INTRODUCTION	BH-1
TECHNICAL DESCRIPTION	
General	BH-2
+20V Power Supply	BH-2
-20V Power Supply	BH-2

Tables

	Table No.
PARTS LIST	
Stabilizer P.C.B. Assembly 19-0027	BH-1
Auxiliary Power Supply Assembly 11-0031	BH-2
COMPONENTS LIST	
Auxiliary Power Supply Assembly 11-0031	BH-3

Illustrations

	Fig.No.
COMPONENT LAYOUTS	
Stabilizer P.C.B. Assembly 19-0027	BH-1 *
Auxiliary Power Supply Assembly 11-0031	BH-2 *
CIRCUIT DIAGRAM	
Auxiliary Power Supply Assembly 11-0031	BH-3

* To be issued later.

INTRODUCTION

Brief Specification

1. The main design features of this auxiliary power supply assembly are as follows:-

Power Supplies	115V/230V (± 10%), 48 c/s - 450 c/s

Outputs	+20V stab (± 0.1V), 100 mA (nominal) -20V stab (± 0.1V), 100 mA (nominal)
Operating Temp.	-10°C to + 70°C

Mains Transformer

2. The auxiliary power supply assembly derives its a.c. power supplies from the mains transformer in power supply assembly 11-0033 (Section BK). For the purposes of the handbook, the mains transformer has been included in the circuit diagram of the auxiliary power supply assembly, Fig. BH-3.

TECHNICAL DESCRIPTION

+20V Power Supply

3. The unstabilized d.c. power supply needed to operate the +20V stabilizer circuit is derived from the full-wave rectifier diodes D2 to D5 and capacitor C2. Overload protection for the mains transformer and the rectifiers is provided by fuse F1.

4. Transistor Q3 is the series stabilizer for the +20V circuit. The conduction of Q3 is controlled by the current through amplifier transistor Q1, which in turn depends on the current output of an error-detecting differential amplifier (Q5 and Q8) and its associated constant-current source (Q7, D12, R9 and R13). Changes in the output voltage on the +20V line are detected by the resistive chain R14, RV1, R16. This produces a change in the current into the base of Q8 and consequently a change in the current through resistor R10. However, as the collector resistor is fed from a constant-current source, any change of current through R10 must be accompanied by an equal and opposite change of current into the base of the amplifier transistor Q1. After amplification in Q1, the current change is further amplified in the series regulator Q3. The final current change in Q3 emitter is of the right phase and magnitude to restore the +20V output to its correct value.

5. Changes in Q5 and Q8 base-emitter voltages with temperature tend to cancel in the differential amplifier circuit arrangement. To minimise changes in Q5 base potential due to the change in Vz (the voltage-drop across the Zener diode D10) with temperature, D10 is chosen to have an extremely low temperature coefficient. The resistance-capacitance circuit R1, C4 is included to prevent the feedback loop going into oscillation.

-20V Power Supply

6. The details and operation of the -20V power supply circuit are exactly the same as for the +20V circuit, except that in this case the constant-current source is provided by the stabilized +20V supply and resistor R11.

TABLE BH-1

PARTS LIST

STABILIZER BOARD 19-0027

Item No.	Part No.	Description	Qty.	Vendor *
1	18-0027	P.C. Board	1	
2				
3	20-0101	Resistor Comp 1/10W 10% 100	2	
4				
5	20-2103	Resistor MO 1/4W 5% 10K	1	
6	20-2122	Resistor MO 1/4W 5% 1.2K	2	
7	20-2152	Resistor MO 1/4W 5% 1.5K	2	
8	20-2222	Resistor MO 1/4W 5% 2.2K	3	
9	20-2681	Resistor MO 1/4W 5% 680	2	
10	20-2682	Resistor MO 1/4W 5% 6.8K	1	
11				
12	20-4750	Resistor M.F. 1/8W 1% 1.5K	2	
13	20-4751	Resistor M.F. 1/8W 1% 1.8K	2	
14	20-6002	Resistor Variable W.W. 500	2	
15	21-0502	Capacitor Elytic 25V 20% + 100% 50	2	
16	21-0503	Capacitor Elytic 50V 20% + 100% 50	1	
17	21-0505	Capacitor Elytic 50V 20% + 100% 500	2	
18	21-1545	Capacitor Cer 18V - 10% 0.01	2	
19				
20	22-1807	Diode Voltage Reg Si 5% 4.7V	1	
21				
22	22-1622	Rectifier Si PIV 100V	9	
23	or			
24	22-1624	Rectifier Si PIV 300V		
25	or			
26	22-1602	Rectifier Si PIV 100V IN4002		
27	or			
28	22-1603	Rectifier Si PIV 200V IN4003		
29				
30	22-1841	Diode Voltage Reg Si Temp Compensated 9V	2	
31	22-6009	Transistor Si NPN 2N4124	6	
32	or			
33	22-6007	Transistor Si NPN 2N3904		
34	22-6010	Transistor Si PNP 2N4126	1	
35	or			
36	22-6008	Transistor Si PNP 2N3906		
37				
38	23-0013	Fuse Holder	2	
39				
40	24-0010	Clip - Spring	2	

* To be issued later

TABLE BH-2

PARTS LIST

POWER SUPPLY ASSEMBLY 11-0031

Item No.	Part No.	Description	Qty.	Vendor *
1	13-0119	Hinge - Large	1	
2	13-0120	Hinge - Small	2	
3				
4	13-0122	Side Member LH	1	
5	13-0123	Side Member RH	1	
6				
7	14-0043	Pin - Hinge	1	
8				
9				
10				
11	19-0027	Aux Power Supply Board Assy.	1	
12				
13	22-6006	Transistor	2	
14				
15	23-0003	Fuse 250 MA	2	
16	23-9001	Heat Sink Adaptor	2	

* To be issued later

TABLE BH-3

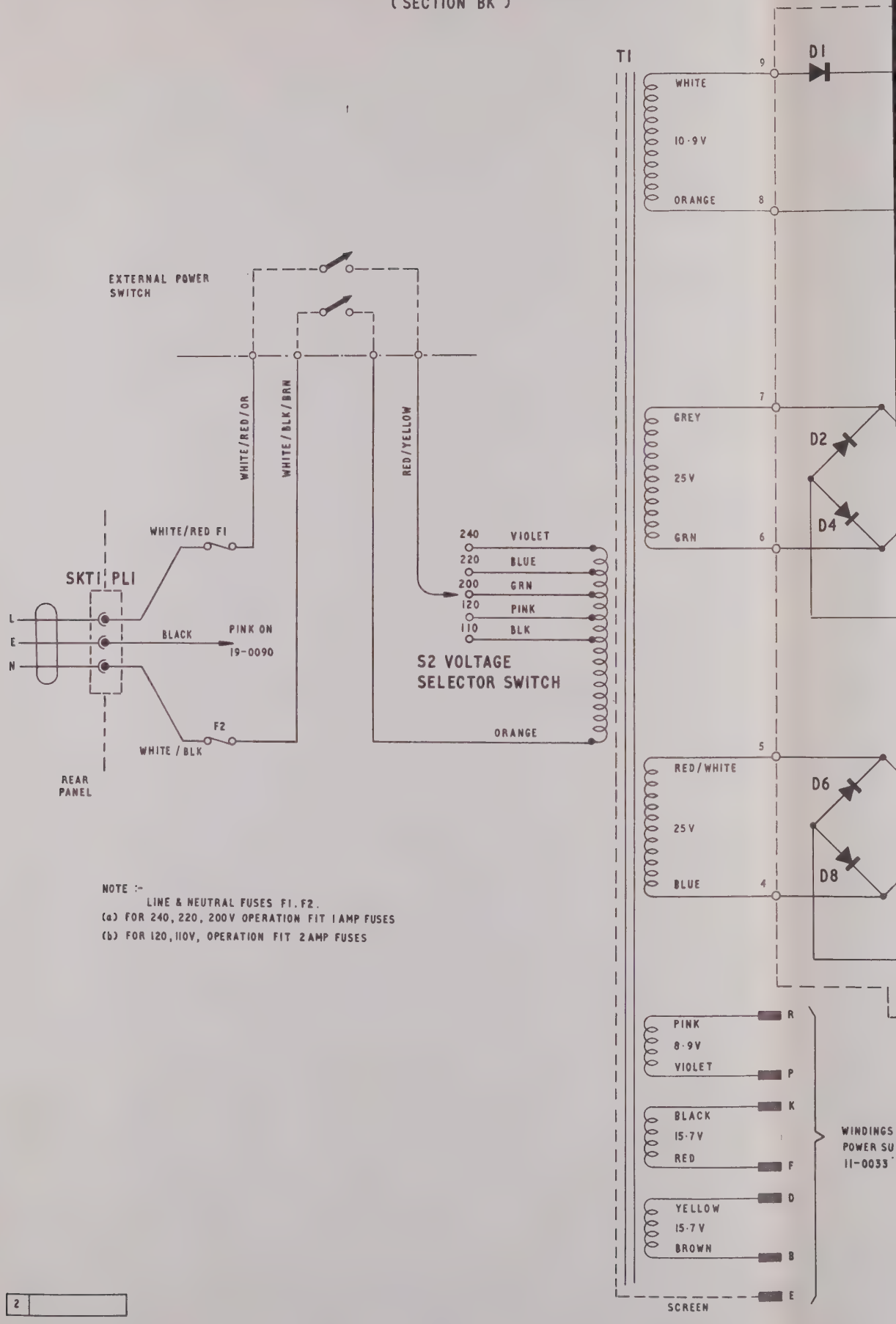
COMPONENT LIST

AUXILIARY POWER SUPPLY ASSEMBLY 11-0031

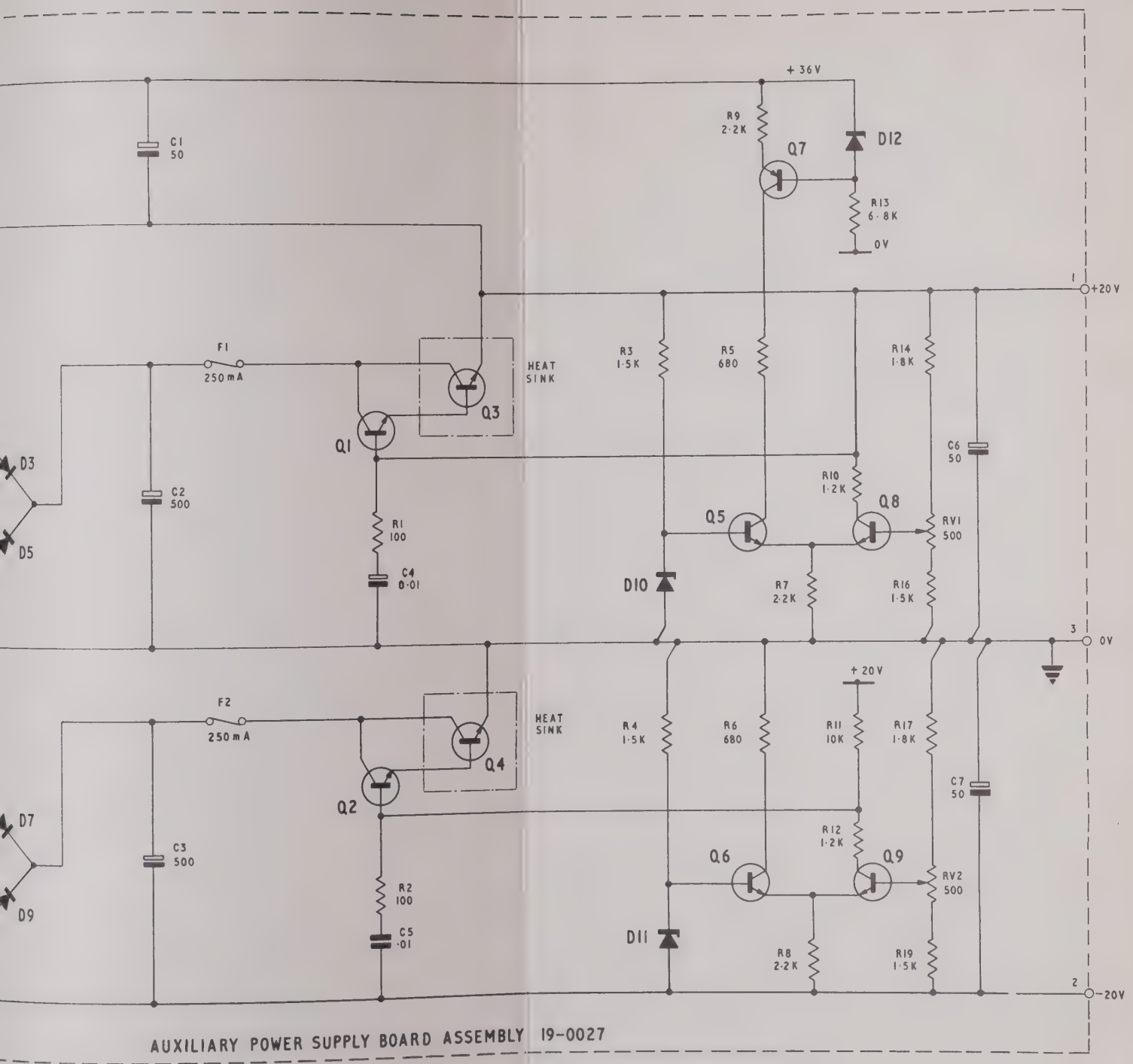
Cct. Ref.	Parts List Reference Item	Table	Physical * Location Grids	Fig.
Resistors				
R1	3	BH-1		
R2	3	BH-1		
R3	7	BH-1		
R4	7	BH-1		
R5	9	BH-1		
R6	9	BH-1		
R7	8	BH-1		
R8	8	BH-1		
R9	8	BH-1		
R10	6	BH-1		
R11	5	BH-1		
R12	6	BH-1		
R13	10	BH-1		
R14	13	BH-1		
R15	14	BH-1		
R16	12	BH-1		
R17	13	BH-1		
R18	14	BH-1		
R19	12	BH-1		
Capacitors				
C1	16	BH-1		
C2	17	BH-1		
C3	17	BH-1		
C4	18	BH-1		
C5	18	BH-1		
C6	15	BH-1		
C7	15	BH-1		
Diodes				
D1	21	BH-1		
D2	21	BH-1		
D3	21	BH-1		
D4	21	BH-1		
D5	21	BH-1		
D6	21	BH-1		
D7	21	BH-1		
D8	21	BH-1		
D9	21	BH-1		
D10	22	BH-1		
D11	21	BH-1		
D12	20	BH-1		
Transistors				
Q1	24	BH-1		
Q2	24	BH-1		
Q3	13	BH-1		
Q4	13	BH-1		
Q5	24	BH-1		
Q6	24	BH-1		
Q7	25	BH-1		
Q8	24	BH-1		
Q9	24	BH-1		
Fuses				
F1	15	BH-2		
F2	15	BH-2		

* To be issued later

PART OF
POWER SUPPLY ASSEMBLY 11-0033
(SECTION BK)



NOTE :-
LINE & NEUTRAL FUSES F1. F2.
(a) FOR 240, 220, 200V OPERATION FIT 1 AMP FUSES
(b) FOR 120, 110V, OPERATION FIT 2 AMP FUSES



Circuit : Auxiliary Power Supply Assembly 11-0031

Fig. BH-3

SECTION BK

TECHNICAL DESCRIPTION

POWER SUPPLY ASSEMBLY 11-0033

CONTENTS

	Page No.
INTRODUCTION	BK-1
TECHNICAL DESCRIPTION	
+12V Power Supply	BK-2
-12V Power Supply	BK-2

Tables

	Table No.
PARTS LISTS	
Rectifier P.C.B. Assembly 19-0088	BK-1
Stabilizer P.C.B. Assembly 19-0090	BK-2
Power Supply Assembly 11-0033	BK-3
COMPONENTS LIST	
Power Supply Assembly 11-0033	BK-4

Illustrations

	Fig. No.
COMPONENT LAYOUTS	
Rectifier P.C.B. Assembly 19-0088	BK-1 *
Stabilizer P.C.B. Assembly 19-0090	BK-2 *
Power Supply Assembly 11-0033	BK-3 *
CIRCUIT DIAGRAM	
Power Supply Assembly 11-0033	BK-4

* To be issued later.

INTRODUCTION

Brief Specification

1. The main design characteristics of the assembly are as follows:-

Power Supplies	115V/230V (± 10%), 48-450 c/s

Outputs	+12V stab (± 0.1V), 1A (nominal) -12V stab (± 0.1V), 1A (nominal)
Operating Temp.	-10°C to + 70°C

Mains Transformer

2. The mains transformer T1 is designed to meet the power supply requirements not only of assembly 11-0033 but also, where the application demands it, those of the auxiliary power supply assembly 11-0031.

TECHNICAL DESCRIPTION

+12V Power Supply

3. The unstabilized d.c. power supply to the +12V stabilizer circuit is derived from the full-wave rectifier diodes D5 to D8, capacitor C2 and resistor R1. Overload protection for the mains transformer and the rectifier diodes is provided by fuse F3.

4. Transistor Q1 is the series stabilizer for the +12V supply. The conduction of Q1 is controlled by the current through transistor Q2, which in turn depends on the current output of an error-sensing stage (Q6) and its associated constant-current source (Q5, D15, R9, R11). Changes in the output voltage on the +12V line are detected via the resistive chain R15, RV1, R17. This produces a change in the current fed into the base of Q6 and, consequently, a change in the current through Q6 collector. However, as the collector of Q6 is fed from a constant-current source, any change of current in the Q6 collector must result in an equal and opposite change of current into the base of Q2. After amplification in Q2, the current change is further amplified in the series stabilizer Q1. The final current change in Q1 emitter is of the current phase and amplitude to restore the +12V output to its right value.

5. To minimize changes in Q6 base potential, Zener diode D13 is chosen to counter-balance the change in Q6 base-emitter voltage with temperature.

-12V Power Supply

6. The details and operation of the -12V power supply circuit are exactly the same as for the +12V circuit, except that in this case, the constant-current source is provided by the +12V supply and resistor R10.

TABLE BK-1

PARTS LIST

RECTIFIER BOARD ASSEMBLY 19-0088

Item No.	Part No.	Description	Qty.	Vendor *
1	18-0088	P.C. Board	1	
2				
3				
4				
5	20-0103	Resistor Comp 1/10W 10% 10K	2	
6				
7				
8				
9	21-0509	Capacitor Elytic 25V 250	1	
10	or			
11	21-0513	Capacitor Elytic 25V 200		
12				
13				
14				
15	22-1622	Rectifier Si Piv 100V	4	
16	or			
17	22-1624	Rectifier Si Piv 300V		
18	or			
19	22-1602	Rectifier Si IN4002 PIV 100V		
20	22-1602	Rectifier Si IN4002 PIV 100V	8	
21	or			
22	22-1603	Rectifier Si IN4003 PIV 200V		
23	or			
24	22-1604	Rectifier Si IN4004 PIV 400V		
25				

* To be issued later

TABLE BK-2

PARTS LIST

STABILIZER BOARD ASSEMBLY 19-0090

Item No.	Part No.	Description	Qty.	Vendor *
1	18-0090	P.C. Board	1	
2				
3				
4				
5	20-2101	Resistor M.O. 1/4W 5% 100	1	
6	20-2122	Resistor M.O. 1/4W 5% 1.2k	2	
7	20-2271	Resistor M.O. 1/4W 5% 270	2	
8	20-2272	Resistor M.O. 1/4W 5% 2.7K	1	
9	20-2332	Resistor M.O. 1/4W 5% 3.3K	1	
10	20-2471	Resistor M.O. 1/4W 5% 470	2	
11	20-2681	Resistor M.O. 1/4W 5% 680	1	
12	20-3181	Resistor M.O. 1/2W 5% 180	1	
13	20-6515	Resistor Variable Comp 500	2	
14				
15				
16				
17	21-0512	Capacitor Elytic 25V 100	2	
18	or			
19	21-0507	Capacitor Elytic 15V 120		
20				
21	21-1545	Capacitor CER 18V 0.01	2	
22				
23				
24				
25	22-1810	Diode Si Zener 5% 6.2V	2	
26	22-1807	Diode Si Zener 5% 4.7V	1	
27	22-6009	Transistor NPN Si 2N4124	4	
28	or			
29	22-6007	Transistor NPN Si 2N3904		
30				
31	22-6010	Transistor PNP Si 2N4126	1	
32	or			
33	22-6008	Transistor PNP Si 2N3906		

* To be issued later

TABLE BK-3

PARTS LIST

POWER SUPPLY ASSEMBLY 11-0033

Item No.	Part No.	Description	Qty.	Vendor *
1	13-0139	Bulkhead-Rear	1	
2	13-0140	Bulkhead-Front	1	
3	13-0141	Plate-Transformer	1	
4	13-0142	Plate-Transformer Mtg.	1	
5	13-0143	Bracket-Capacitor Mtg.	1	
6	13-0144	Bracket-Fuse Mtg.	1	
7	13-0146	Bracket-Tag	1	
8	13-0159	Bracket-Tag	1	
9	13-0160	Cover Transistor	1	
10	13-0161	Bracket-Tag	1	
11				
12				
13				
14	15-0017	Spacer Tapex Special	2	
15	15-0023	Spring	2	
16	15-0024	Heat Sink	1	
17				
18				
19				
20	17-4004	Transformer	1	
21				
22				
23				
24	19-0088	Rectifier Power Assy.	1	
25	19-0090	Stabilised Power Assy.	1	
26				
27				
28				
29	21-0506	Capacitor Elytic 40V 2500	2	
30				
31	or			
32	21-0510	Capacitor Elytic 40V 2500		
33	or			
34	21-0511	Capacitor Elytic 40V 3600		
35				
36				
37				
38	22-6011	Transistor NPN Si	2	
39				

Item No.	Part No.	Description	Qty.	Vendor *
40				
41				
42	23-0006	Fuse Link 1 Amp	2	
43	23-0008	Fuse Link 2 Amp	2	
44	23-0014	Fuseholder	4	
45	23-3032	Socket 5x2 Way-Selector	1	
46	23-3035	Plug Shorting-Red	1	
47	23-3036	Receptical Male 3 Pins Power	1	
48	23-5036	Connector P.C. Board	2	
49	23-9002	Washer-Insulating	2	
50	23-9003	Bush-Insulating	4	
51				
52	24-0017	Lok-Strap	2	

* To be issued later

TABLE BK-4

COMPONENTS LIST

POWER SUPPLY ASSEMBLY 11-0033

Cct. Ref.	Parts List Reference Item	Table	Physical * Location Grids	Fig.
Resistors Fixed				
R1	5	BK-1		
R2	5	BK-1		
R3	5	BK-2		
R4	12	BK-2		
R5				
R6				
R7	6	BK-2		
R8	6	BK-2		
R9	11	BK-2		
R10	8	BK-2		
R11	9	BK-2		
R12	7	BK-2		
R13				
R14	10	BK-2		
R15	7	BK-2		
R16				
R17	10	BK-2		
Resistors Variable				
RV1	13	BK-2		
RV2	13	BK-2		
Capacitors				
C1	9	BK-1		
C2	29	BK-3		
C3	29	BK-3		
C4	21	BK-3		
C5	21	BK-3		
C6	17	BK-2		
C7	17	BK-2		
Diodes				
D1	15	BK-1		
D2	15	BK-1		
D3	15	BK-1		
D4	15	BK-1		
D5	20	BK-1		
D6	20	BK-1		
D7	20	BK-1		
D8	20	BK-1		
D9	20	BK-1		
D10	20	BK-1		
D11	20	BK-1		
D12	20	BK-1		
D13	25	BK-2		
D14	25	BK-2		
D15	26	BK-2		
Transistors				
Q1	38	BK-3		
Q2	27	BK-2		
Q3	38	BK-3		
Q4	27	BK-2		
Q5	31	BK-2		
Q6	27	BK-2		
Q7	27	BK-2		
Transformers				
T1	20	BK-3		
Fuses				
F1	42	BK-3		
F2	42	BK-3		
F3	43	BK-3		
F4	43	BK-3		

* To be issued later

SECTION CB

TECHNICAL DESCRIPTION

BI-QUINARY SCALER P.C.B. ASSEMBLY 19-0049

CONTENTS

	Page No.
INTRODUCTION	CB-2
Function	CB-2
Brief Electrical Specification	CB-2
TECHNICAL DESCRIPTION	CB-2
General	CB-2
Input Amplifier	CB-2
Shaper and Level Set	CB-3
Quinary Frequency Divider	CB-5
Shaper	CB-8
Binary Frequency Divider	CB-9

Tables

	Table No.
PARTS LIST	CB-1
COMPONENTS LIST	CB-2

Illustrations

	Fig. No.
EXPLANATORY DIAGRAMS	
Functional Block Diagram of Assembly	CB-1
Functional Diagram of Quinary Frequency Divider	CB-2
COMPONENT LAYOUT	CB-3*
CIRCUIT DIAGRAM	CB-4

* To be issued later

INTRODUCTION

Function

1. The overall function of this assembly is that of a decade frequency divider, the division being accomplished by combining binary division in a 20kHz to 20MHz bistable flip-flop with quinary (scale-of-five) division as provided by a 100kHz to 100MHz ring circuit.

Brief Electrical Specification

2. The principal design characteristics of the assembly are as follows:-

Input frequency range	100kHz to 100MHz
Input impedance	50 ohm
Sensitivity	100mV r.m.s.
Maximum input level	1V r.m.s.
Output frequency range	10kHz to 10MHz
Output level	300mV r.m.s. into 500 ohm
Power supplies	+20V at 100mA -20V at 85 mA +12V at 160mA -12V at 60mA

TECHNICAL DESCRIPTION

General

3. For descriptive purposes the assembly circuits are broken down according to function (Fig. CB-1 refers).

(a) Input amplifier (Q1 to Q4)

(b) Shaper and level set (Q5 to Q8)

(c) Quinary frequency divider (Q9 to Q18)

(d) Shaper (Q19, Q20)

(e) Binary frequency divider (Q21, Q22, Q23)

Input Amplifier (Q1 - Q4) (Fig. CB-4)

4. This consists of an input emitter-follower (Q1) followed by two identical emitter-coupled wideband amplifier stages (Q2 and Q3) and an output emitter follower (Q4).

5. The signal fed to emitter-follower Q1 is first developed across the input

circuit comprising resistor R1 in parallel with the potentiometer RV1. This enables the effective sensitivity of the amplfier to be set as required between the limits 25 to 30mV r.m.s. (RV1 fully clockwise) and zero (RV1 fully counter-clockwise).

6. The amplifier stages incorporate circuits for d.c. voltage stabilisation (R10, C5, R17 and C10) and to provide additional amplification at the higher frequencies (R11, C8, R18 and C13). The trimmer capacitors C7 and C12 in Q2 and Q3 emitter circuits enable the amplifier to be tuned for optimum response over the passband.

7. The collector and emitter load resistors R8 and R9 in amplifier Q3 are chosen such that the stage gain (nominally R8/R9) is in the region of 4. Coupled with the gain of the following stage, this gives an overall voltage gain for the amplifier of the order of 16.

8. In the output emitter-follower stage, Q5, of the overall amplifier circuit, the base potential of the transistor is set to the required value by the potentiometer RV2 connected in series with resistors R19 and R21 across the positive and negative 20V supply lines. The diode, D1, through which the signal is coupled to the next stage, i.e. transistor Q5, is chosen to have an equal but opposite temperature coefficient to that of Q4, thereby ensuring that any changes in Q4 base-emitter voltage with temperature cancel out in the diode.

9. Decoupling circuits are embodied in the collector circuits of both the input and output emitter-follower circuits of the amplifier (R5, C4, R22, C16 and C17) for the joint purpose (1) of keeping down the power dissipated in the transistors and (2) preventing inter-stage coupling via the +12V power supply. The collector circuits of the amplifier stages Q3 and Q4 are also decoupled from the +12V, Q2 collector by R7 and C6 and Q3 collector by R14 and C11. Finally, the potential divider R19, RV2 and R21 is decoupled from both 20V supply lines (positive and negative) by capacitors C52 and C53. This last bit of decoupling is necessary because of the unavoidably long leads connecting the fixed resistors in the chain to their respective power supplies.

Shaper and Level Set (Fig. CB-4)

10. The shaper and level set circuit consists of an emitter-coupled bistable circuit (Q5 and Q6) followed by complimentary p-n-p and n-p-n emitter-followers (Q7 and Q8).

11. Principle of Operation of Shaper. Assume to begin with that transistor Q6 is conducting. In this state of the circuit a current Ic flows in the collector circuit of Q6. The current Ie flowing in the common emitter load resistor R27 is equal to Ic. The current I_1 in resistor R30 depends for its value on the +9.1V supply, the value of resistor R26 and the volts-drop Vz across the Zener-diode D3. The current I_2 in resistor R26 is equal to I_1 and the base potential V_1 of Q6 is positive with respect to 0V. Provided that the input signal voltage Vin is negative relative to V_1, transistor Q6 will continue to conduct.

12 Assume now that the other transistor, Q5, is conducting. The current I_2 is now equal to I_1 + Ie and, due to the constant volts-drop across the Zener D3, the base potential V_1 of Q6 is less positive than when Q6 was conducting. Provided that the input signal voltage Vin is positive relative to this new value of V_1, Q5 will continue to conduct.

13. Clearly, therefore, the circuit has two stable states, viz:-

(1) Q6 conducting when Vin is negative relative to V_A (where V_A is the value of V_1 when Q6 is conducting).

(2) Q5 conducting when Vin is positive relative to V_B (where V_B is the value of V_1 when Q5 is conducting).

14. Assume the circuit to be in state (1). If Vin changes in a positive-going direction, Q5 will start to conduct. Regeneration will occur and the circuit will assume state (2). The application of a negative-going input voltage Vin will cause the circuit to revert to state (1). If a sinewave of peak-to-peak amplitude in excess of $V_A - V_B$ is applied to the circuit a square wave output will be produced. The operation of the circuit is very similar to that of a Schmitt trigger.

15. Practical Features of the Shaper Circuit. The collector resistors R26 and R28 of transistors Q5 and Q6 are referenced to +9.1V and +5.6V respectively by the Zener-diodes D2 and D4. The +9.1V reference, resistor R27 and the -20V supply form a constant-current source for Q5 when it is conducting. Similarly, the +5.6V reference, R27 and the -20V supply form a constant-current source for the other transistor, Q6, when it is conducting. If the current flowing in Q6 is constant, the aperture of the circuit ($V_A - V_B$) will also be constant.

16. When transistor Q5 is conducting, the potential at the collector of Q6 is determined by the volts-drop across the potential divider comprising R28, RV3 and R32. Since R28 is referenced to a stable +5.6V supply, this arrangement gives a very well defined voltage level at Q6 collector when the transistor is non-conducting.

17. The current flowing in Q6 when it is conducting is defined at approximately 10mA by the +5.6V reference, resistor R27 and the -20V supply. Since this is a constant current, the voltage level at the collector of Q6 when the transistor is conducting is also well defined.

18. Clearly, the output at Q6 collector as the circuit switches from one stable state to the other is a square wave in which the upper and lower levels and the point of transition from one to the other are controlled to within very close limits.

19. Capacitors C18 to C22 are included in the shaper circuit to decouple it from the +12V and -20V supplies, thereby ensuring that the fast counting currents being switched in Q5 and Q6 do not interfere or interact with any other part of the circuitry. Capacitors C18, C20 and C22 provide the necessary decoupling at the lower frequencies and C19 and C21 that at the higher frequencies.

20. The Zener-diode D3 is used for cross-coupling rather than a resistor and capacitor because (a) it has a very low impedance and gives the required voltage difference between Q5 base and Q6 collector and (b) it is a more efficient coupling. Inductor L1 in the collector circuit of transistor Q6 is included to provide a measure of high-frequency boost up to 140MHz approximately.

21. Emitter-followers Q7 and Q8 This arrangement of an n-p-n emitter-follower (Q7) followed by a p-n-p emitter-follower (Q8) gives very good temperature compensation. Diode D4 is a zero temperature coefficient Zener, hence the constant-amplitude square wave at Q6 collector is reproduced at the emitter of Q8 unaffected by temperature variations.

22. The collector circuits of the emitter-followers include large-value capacitors to decouple the low frequencies (C23 and C27) and smaller value capacitors (C25 and C28) to provide the high frequency decoupling. High frequency decoupling cpacitors (C24 and C26) are also included across the emitter -12V supplies to earth.

Quinary Frequency Divider (Figs. CB-2 & CB-4)

23. General. The quinary frequency divider consists of five identical Schmitt type trigger circuits connected in cascade to form a closed loop or ring. Its input, which comes from Q8 emitter via the network R59, C42, is a 2V constant-amplitude square wave (limits 2.5V and 4.5V) d.c. referenced to earth. This is applied to all five elements of the ring at one and the same time, with the following general results.

24. For any one transition of the input square wave between 2.5V and 4.5V (positively or negatively) one element only of the ring changes its state. The effect of this on the following element is to bias it such that it will change state on the succeeding transition. This action continues on round the ring until, after ten transitions of the input (five complete cycles), each element will have changed its state twice, thus bringing the ring back to the condition from which it started.

25. Overall, the ring has a total of ten stable states it can be in, depending on the level of the input and the number of transitions received. The output waveform is not a square wave but a 'stepped' waveform at one fifth the frequency of the input.

26. Detailed Circuit Operation. Assume for the purposes of the following description (a) that the input is at its upper level of +4.5V and (b) that the condition of the ring is as shown in Fig. CB-2, response (1). The individual stable states of the various elements of the ring under these conditions are summarised in the following table.

ELEMENT	TRANSISTOR	STABLE STATES
1	Q9	+
	Q10	⊖
2	Q11	-
	Q12	+
3	Q13	+
	Q14	-
4	Q15	-
	Q16	+
5	Q17	+
	Q18	-

+ = conducting
- = cut-off
⊕ = just conducting
⊖ = just cut-off

27. The state of the input waveform depends on the state of the main shaper circuit of the board, Q5 and Q6. It is at its upper level of 4.5V when transistor Q6 of the shaper is non-conducting.

28. Assuming that the shaper circuit changes over to its other stable state, as Q6 comes back on again the input to the ring will fall negatively towards +2.5V. Transistor Q9 of element 1 is conducting, hence the fall in voltage at its base is reproduced at the emitter (but at a slightly lower level because of the volts-drop across Q9 base-emitter junction). As the input voltage continues to fall, the point is eventually reached at which the forward threshold of transistor Q10 is exceeded. When this happens, Q10 starts to conduct and element 1 quickly changes over to become stable again with Q10 fully conducting and Q9 cut-off.

29. In the transition of element 1 from one stable state to the other, the current flow in Q9 collector (10mA approximately) is diverted through the Zener-diode D5, causing the base potential of Q10 to rise to +5.5V (originally it was +3.0V). Secondly, the current previously flowing in resistor R40, R43 and Zener-diode D6 (when Q10 was cut-off) now flows through the collector of Q10, thereby causing the base potential of transistor Q12 in element 2 to fall to +3.5V (before, it was +5.5V).

30. After the input to the ring has gone negative from +4.5V to +2.5V, therefore, element 1 will have changed over to the condition Q9 cut-off, Q10 conducting and element 2 will have changed its condition to Q11 cut-off, Q12 just conducting. The condition of elements 3, 4 and 5 remains the same as it was before the positive-going transition of the input. The two stable states of the ring (1) before the input went negative and (2) after the negative-going transition, are as follows.

ELEMENT	TRANSISTOR	STABLE STATE (1)	(2)
1	Q9	+	-
	Q10	⊖	+
2	Q11	-	-
	Q12	+	⊕
3	Q13	+	+
	Q14	-	-
4	Q15	-	-
	Q16	+	+
5	Q17	+	+
	Q18	-	-

+ = conducting
- = cut-off
⊕ = just conducting
⊖ = just cut-off

31. Assume now that the main shaper circuit (Q5 and Q6) reverts to its original condition. As transistor Q6 goes off, the input to the ring will rise again to its upper level of +4.5V. As the input voltage increases, it passed through the level at Q12 emitter (+2.7V approximately, allowing for a base-emitter volts-drop of the order of 0.8V). When it reaches +3.3V, the input voltage exceeds the common emitter potential by an amount equal to the forward threshold of Q12 (0.6V). At this point, transistor Q11 of element 2 starts to conduct and the element rapidly changes its state to become stable again with Q11 fully conducting and Q12 fully off.

32. As element 2 changes its state, the current in the Zener D6 is diverted into Q11 collector, causing the base potential of Q12 to fall to +1.0V. Also, the current which previously flowed in Q12 when it was conducting (10mA approximately) now flows through resistor R43 and the Zener-diode of element, D, as a result of which Q14 base potential rises up to +3.0V.

33. After the input to the ring has gone positive from +2.5V to 4.5V, therefore, element 2 will have changed over to the condition Q11 conducting, Q12 cut-off and element 3 will have changed its condition to Q13 conducting, Q14 just cut-off. The condition of elements 1, 4 and 5 remains the same as it was before the positive-going transition of the input. The three stable states of the ring (1) corresponding to the conditions assumed to exist at some point or other in the complete cycle of events round the ring, (2) one input voltage transition (negative-going) later and (3) two input voltage transitions (negative-going followed by positive-going) later, may be summarized as follows.

ELEMENT	TRANSISTOR	STABLE STATES OF RING (1)	(2)	(3)
1	Q9	+	-	-
	Q10	⊖	+	+
2	Q11	-	-	+
	Q12	+	⊕	-
3	Q13	+	+	+
	Q14	-	-	⊖
4	Q15	-	-	-
	Q16	+	+	+
5	Q17	+	+	+
	Q18	-	-	-

+ = conducting
- = cut-off
⊕ = just conducting
⊖ = just cut-off

34. When next the input voltage to the ring changes back again from +4.5V to +2.5V, this will change the condition of elements 3 and 4 in exactly the same way as it did elements 1 and 2. As the input voltage continues to change from one level to the other and back again, this action continues around the ring until eventually, after ten changes of state, the ring comes back to the condition from which it started. The complete cycle of operations is summarised in the table following, which gives the stable states of the ring elements corresponding to the waveform sequence in Fig. CB-2, response (2).

ELEMENT	TRANSISTOR	INPUT VOLTAGE TRANSITIONS 0	1	2	3	4	5	6	7	8	9	10
1	Q9	-	-	-	+	+	+	+	+	-	-	-
	Q10	+	+	⊕	-	-	-	-	⊖	+	+	+
2	Q11	+	+	+	+	-	-	-	-	-	+	+
	Q12	-	-	-	⊖	+	+	+	+	⊕	-	-
3	Q13	-	-	-	-	-	+	+	+	+	+	-
	Q14	+	+	+	+	⊕	-	-	-	-	⊖	+
4	Q15	-	+	+	+	+	+	-	-	-	-	-
	Q16	⊕	-	-	-	-	⊖	+	+	+	+	⊕
5	Q17	+	+	-	-	-	-	-	+	+	+	+
	Q18	-	⊖	+	+	+	+	⊕	-	-	-	-

+ = conducting
- = cut-off
⊕ = just conducting
⊖ = just cut-off

Shaper (Q19 and Q20) (Fig. CB-4)

35. The shaper circuit of the board consists of an emitter-follower (Q19), a

differentiating circuit (C44 and R65) and a common-emitter amplifier (Q20).

36. The emitter-follower acts as buffer for the ring, providing the same output but at low impedance. The collector circuit of this stage is decoupled from the +12V supply rail by resistor R63 and the low-frequency decoupling capacitor C43.

37. In the differentiating circuit the values of C44 and R65 are chosen such that time-constant is longer than five times the longest input period that the ring is designed to accept. Assuming that the ring is designed to operate from inputs as low as 100kHz, this means that the time-constant has to be longer than five times 10 microsec. (the corresponding period), i.e. longer than 50 microsec.

38. Consider a time when the output of the ring is changing in level from +5.5V to +3.5V. This 2V negative-going edge is coupled via the emitter-follower (Q19) and capacitor C4 to the base of the amplifier transistor Q20. Normally, Q20 is held in conduction by the current flowing into its base via resistor R65. As soon as the negative-going edge reaches Q20 base the transistor is turned off.

39. When the next negative-going edge (+3.5V to +1.0V) occurs, the condition of Q20 remains unchanged, insufficient time having elapsed for Q20 to come back on again. For each two negative-going input transitions, therefore, the shaper gives one positive-going edge at its output.

40. Normally, transistor Q20 should be conducting again by the time the ring output goes positive from +1.0V to +3.0V. If not already conducting then it will be made to do so on the arrival of this edge at its base. Once Q20 is conducting, it is held in this state by the current through resistor R65 and also by the following positive-going edge (+3.0V to +5.5V).

41. The fact that at the higher frequencies Q20 tends to stay cut-off longer than at the lower frequencies does not affect the operation of the circuit. This is because the transistor would in any case be turned back on again at least by the time the first positive-going edge occurred. In fact at these higher frequencies the shaper circuit acts just like an amplifier, the transistor being driven fully into cut-off by the first negative-going edge to occur and into full conduction by the first positive-going edge of each output cycle.

42. The positive end of resistor R67 in the collector of Q20 is returned to a 6.2V Zener-diode, D10. The transistor output is a rectangular-shaped waveform with the same repetition frequency as, but 180 degrees out-of-phase with, the output of the ring.

Binary Frequency Divider (Q21, Q22 and Q23) (Fig. CB-4)

43. Transistors Q21, Q22 and their associated components form a fast-operating bistable flip-flop capable of operating at frequencies in excess of 20MHz. The only unconventional feature of the circuit is that it is fed from a low-voltage

(6V) supply, not from the existing 12V supply. To enable the circuit to operate satisfactorily at the higher frequencies entails having very low collector time constants and therefore drawing relatively large currents from the +12V supply. By using half the available voltage (6V instead of 12V) smaller currents can be drawn for a given collector resistor value (and therefore time constant) thus reducing power to one quarter of its original value.

44. The binary frequency divider is followed by a conventional emitter-follower (Q23) to provide low-impedance drive across the output terminals.

TABLE CB-1

PARTS LIST

BI-QUINARY SCALER ASSEMBLY 19-0049

Item No.	Part No.	Description	Qty.	Vendor *
1	18-0049	Board P.C.	1	
2				
3				
4				
5	20-0221	Resistor Comp 1/10W 10% 220	1	
6	20-0472	Resistor Comp 1/10W 10% 4.7K	1	
7	20-2102	Resistor MO 1/4W 5% 1K	2	
8	20-2182	Resistor MO 1/4W 5% 1.8K	33	
9	20-2183	Resistor MO 1/4W 5% 18K	1	
10	20-2222	Resistor MO 1/4W 5% 2.2K	4	
11	20-2331	Resistor MO 1/4W 5% 330	8	
12	20-2391	Resistor MO 1/4W 5% 390	5	
13	20-2392	Resistor MO 1/4W 5% 3.9K	3	
14	20-2470	Resistor MO 1/4W 5% 47	3	
15	20-2562	Resistor MO 1/4W 5% 5.6K	4	
16	20-2681	Resistor MO 1/4W 5% 680	2	
17	20-2682	Resistor MO 1/4W 5% 6.8K	1	
18	20-2821	Resistor MO 1/4W 5% 820	1	
19	20-2822	Resistor MO 1/4W 5% 8.2K	1	
20	20-3100	Resistor MO 1/2W 5% 10	1	
21	20-3121	Resistor MO 1/2W 5% 120	1	
22	20-3151	Resistor MO 1/2W 5% 150	1	
23	20-3272	Resistor MO 1/2W 5% 2.7K	1	
24	20-4000	Resistor MO 1/4W 2% 68	7	
25	20-4001	Resistor MO 1/4W 2% 120	1	
26	20-4002	Resistor MO 1/2W 2% 100	1	
27	20-4003	Resistor MO 1/2W 2% 270	2	
28	20-4004	Resistor MO 1/2W 2% 330	1	
29	20-4005	Resistor MO 1/2W 2% 390	5	
30	20-4006	Resistor MO 1/2W 2% 560	5	
31	20-4007	Resistor Comp 1/2W 2% 2.2K	6	
32				
33				
34				
35	20-6510	Resistor Var 20% 100	1	
36	20-6513	Resistor Var 20% 1.5K	1	
37	20-6514	Resistor Var Log 10K	1	
38				
39				
40				

* To be issued later

Item No.	Part No.	Description	Qty.	Vendor *
41				
42				
43	21-1001	Capacitor TA. 25V 5	1	
44	21-1002	Capacitor TA. 15V 10	8	
45	21-1511	Capacitor Cer 500V 10% 18p	2	
46	21-1515	Capacitor Cer 500V 10% 39p	2	
47	21-1552	Capacitor Cer 12V 0.1	12	
48	21-1558	Capacitor Cer 150V 10% 5.6p	1	
49	21-1585	Capacitor Cer 150V 10% 0.001	21	
50				
51				
52	21-1589	Capacitor Cer 6V-25+50% 0.22	2	
53	21-2507	Capacitor S/Mica 5% 27p	2	
54	21-6002	Capacitor Variable 4.5/20p	2	
55				
56				
57				
58	22-0001	Diode GE	1	
59	22-~~1001~~1810	Diode Zener 5% 6.2V	1	
60	22-1006	Diode Si	4	
61	22-~~1007~~1814	Diode Zener 5% 9.1V	1	
62	22-1010	Diode Zener 5% 5.6V	7	
63				
64				
65				
66				
67				
68	22-6000	Transistor Si pnp	1	
69	22-6001	Transistor Si npn	15	
70	22-6004	Transistor Si npn	7	
71				
72				
73				
74	23-7000	Inductance 0.22	1	

* To be issued later

TABLE CB-2

COMPONENTS LIST

BI-QUINARY SCALER P.C.B. ASSEMBLY 19-0049

Cct. Ref.	Parts List Reference		Physical * Location		Cct. Ref.	Parts List Reference		Physical * Location	
	Item	Table	Grids	Fig.		Item	Table	Grids	Fig.
Resistors Fixed									
R1	25	CB-1			R36	16	CB-1		
R2					R37	18	CB-1		
R3	15	CB-1			R38	24	CB-1		
R4	15	CB-1			R39	20	CB-1		
R5	11	CB-1			R40	30	CB-1		
R6	10	CB-1			R41	31	CB-1		
R7	11	CB-1			R42	29	CB-1		
R8	11	CB-1			R43	24	CB-1		
R9	24	CB-1			R44	31	CB-1		
R10	10	CB-1			R45	30	CB-1		
R11	14	CB-1			R46	29	CB-1		
R12	15	CB-1			R47	24	CB-1		
R13	15	CB-1			R48	31	CB-1		
R14	11	CB-1			R49	30	CB-1		
R15	11	CB-1			R50	29	CB-1		
R16	24	CB-1			R51	24	CB-1		
R17	10	CB-1			R52	31	CB-1		
R18	14	CB-1			R53	30	CB-1		
R19	17	CB-1			R54	29	CB-1		
R20					R55	24	CB-1		
R21	19	CB-1			R56	31	CB-1		
R22	11	CB-1			R57	30	CB-1		
R23	8	CB-1			R58	29	CB-1		
R24	6	CB-1			R59	14	CB-1		
R25	21	CB-1			R60				
R26	27	CB-1			R61	13	CB-1		
R27	31	CB-1			R62	8	CB-1		
R28	27	CB-1			R63	12	CB-1		
R29	11	CB-1			R64	12	CB-1		
R30	26	CB-1			R65	9	CB-1		
R31					R66	22	CB-1		
R32	23	CB-1			R67	11	CB-1		
R33	5	CB-1			R68	13	CB-1		
R34	10	CB-1			R69	12	CB-1		
R35	16	CB-1			R70	7	CB-1		

* To be issued later

Cct. Ref.	Parts List Reference Item	Table	Physical * Location Grids	Fig.
R71	7	CB-1		
R72	12	CB-1		
R73	13	CB-1		
R74	12	CB-1		
R75	8	CB-1		
Resistors Variable				
RV1	35	CB-1		
RV2	36	CB-1		
RV3	37	CB-1		
Capacitors Fixed				
C1	44	CB-1		
C2	44	CB-1		
C3	47	CB-1		
C4	47	CB-1		
C5	52	CB-1		
C6	47	CB-1		
C7	54	CB-1		
C8	53	CB-1		
C9	47	CB-1		
C10	52	CB-1		
C11	47	CB-1		
C12	54	CB-1		
C13	53	CB-1		
C14	47	CB-1		
C15	49	CB-1		
C16	47	CB-1		
C17	49	CB-1		
C18	49	CB-1		
C19	44	CB-1		
C20	49	CB-1		
C21	44	CB-1		
C22	49	CB-1		
C23	47	CB-1		
C24	49	CB-1		
C25	49	CB-1		
C26	49	CB-1		
C27	47	CB-1		
C28	49	CB-1		
C29	44	CB-1		
C30	49	CB-1		
C31	43	CB-1		
C32	49	CB-1		
C33	49	CB-1		
C34	49	CB-1		
C35				
C36	49	CB-1		
C37	49	CB-1		
C38	49	CB-1		
C39	49	CB-1		
C40	49	CB-1		
C41	49	CB-1		
C42	48	CB-1		
C43	47	CB-1		
C44	44	CB-1		
C45	44	CB-1		
C46	45	CB-1		
C47	45	CB-1		
C48	46	CB-1		
C49	46	CB-1		
C50	47	CB-1		
C51	44	CB-1		
C52	49	CB-1		
C53	49	CB-1		
C54	47	CB-1		

* To be issued later

Cct. Ref.	Parts List Reference		Physical * Location		Cct. Ref.	Parts List Reference		Physical * Location	
	Item	Table	Grids	Fig.		Item	Table	Grids	Fig.
Diodes					**Transistors**				
D1	58	CB-1			Q1	70	CB-1		
D2	61	CB-1			Q2	70	CB-1		
D3	62	CB-1			Q3	70	CB-1		
D4	62	CB-1			Q4	70	CB-1		
D5	62	CB-1			Q5	70	CB-1		
D6	62	CB-1			Q6	70	CB-1		
D7	62	CB-1			Q7	70	CB-1		
D8	62	CB-1			Q8	68	CB-1		
D9	62	CB-1			Q9	69	CB-1		
D10	59	CB-1			Q10	69	CB-1		
D11	60	CB-1			Q11	69	CB-1		
D12	60	CB-1			Q12	69	CB-1		
D13	60	CB-1			Q13	69	CB-1		
D14	60	CB-1			Q14	69	CB-1		
					Q15	69	CB-1		
					Q16	69	CB-1		
Inductors					Q17	69	CB-1		
L1	74	CB-1			Q18	69	CB-1		
					Q19	69	CB-1		
					Q20	69	CB-1		
					Q21	69	CB-1		
					Q22	69	CB-1		
					Q23	69	CB-1		

* To be issued later

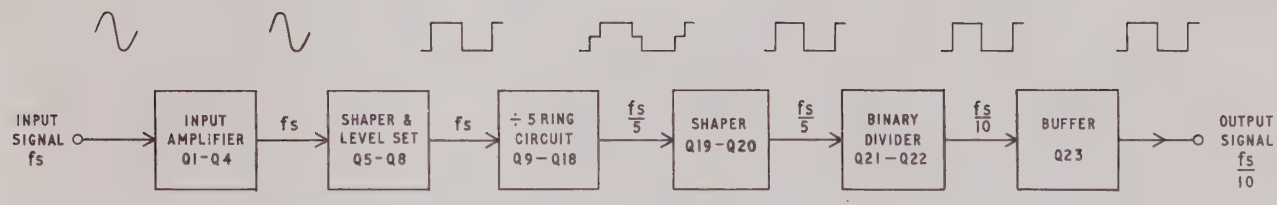
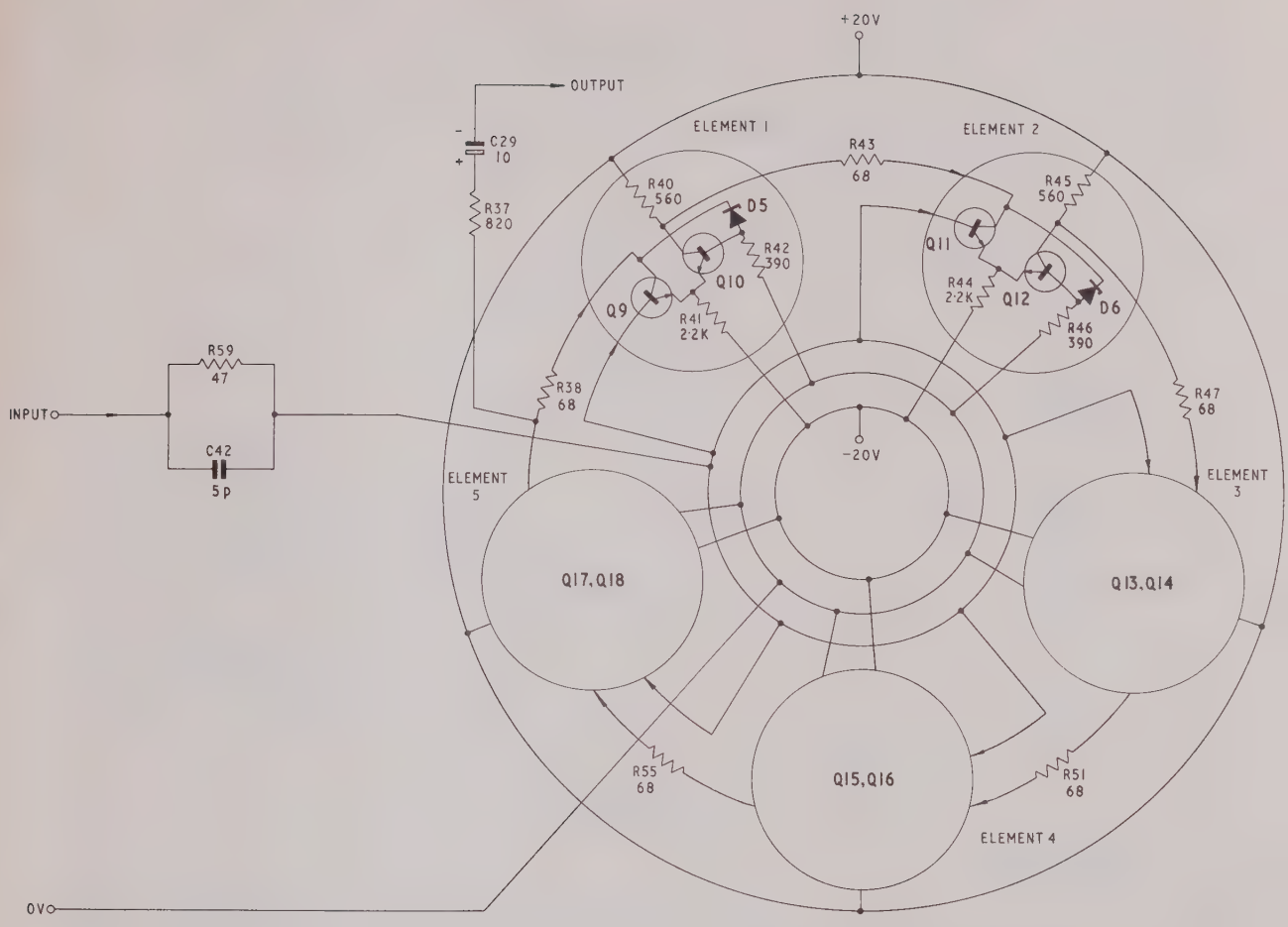
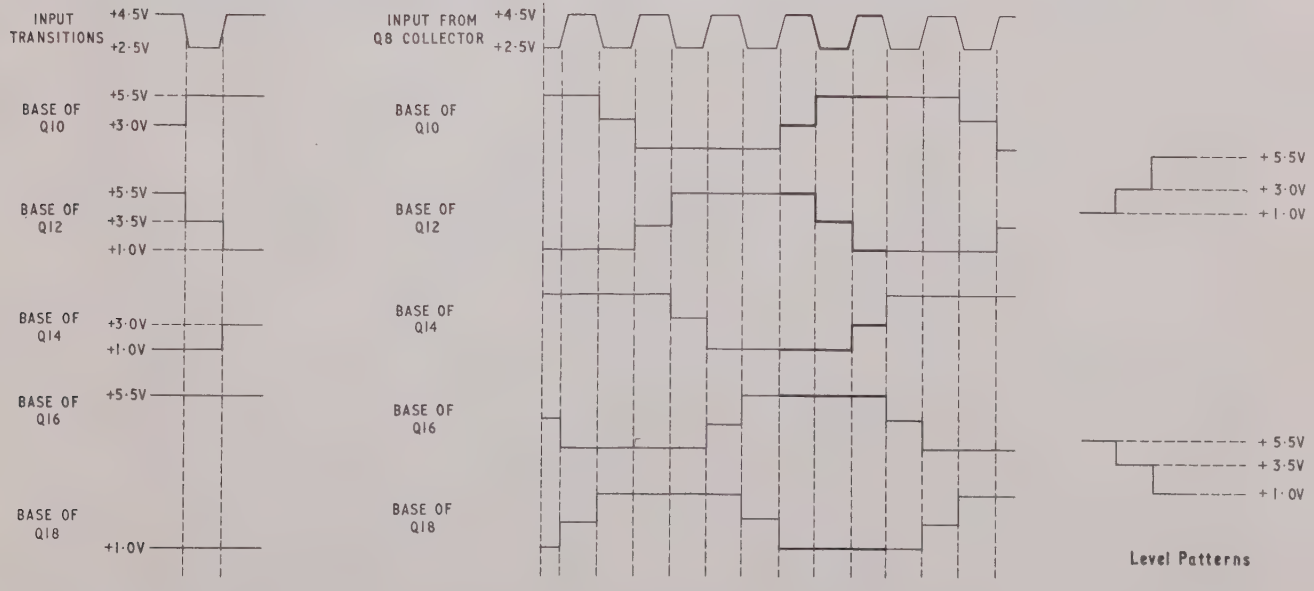


Fig. CB-1 Functional Block Diagram



Quinary Ring Divider: Simplified Circuit



(1)
Typical Response During 1 Cycle Of The Input

(2)
Overall Response

Quinary Frequency Divider : Functional Diagram Fig. CB-2

SECTION 8

ADDITIONAL ASSEMBLY INFORMATION

CONTENTS

Tables

	Table No.
PARTS LISTS	
Instrument Assembly SA. 541	8-1
Chassis Assembly 11-0001	8-2
Attenuator Assembly 11-0116	8-3
Attenuator P. C. B. Assembly 19-0061	8-4
COMPONENTS LIST	
Instrument Assembly SA. 541	8-5

Illustrations

	Fig. No.
COMPONENT LAYOUTS	
Attenuator P. C. B. Assembly 19-0061	8-1*
Instrument Assembly SA. 541	8-2*
INTERCONNECTIONS BETWEEN MAIN ASSEMBLIES	
Instrument Assembly SA. 541	8-3

* To be issued later

TABLE 8-1

PART LIST

AUTOMATIC FREQUENCY CONVERTER SA.541

Item No.	Part No.	Description	Qty.	Vendor *
1	11-0001	Chassis Assy SA565/541	1	
2	11-0031	Aux. Power Supply Assy	1	
3	11-0000	G/A 500 Mhz Package	1	
4				
5	13-0108	Cover Base	1	
6	13-0109	Cover	1	
7	13-0110	Hood	1	
8	13_0010	Casting Runner	2	
9	13-0129	Front Panel	1	
10				
11				
12	14-0021	Spacer	2	
13	19-0049	100 Mhz Pre-Scaler Assy	1	
14	10-2009	Cable Assy R.F.	1	
15	24-0011	Foot	4	
16	BD 18048/15	Handle	2	
17	AD 4530	Ferrule	4	
18	AD 4957	Washer	4	
19	AD 21239	Special Screw	4	
20	AD 26240	Knob ($\frac{1}{4}$ Dia Shaft)	1	
21	AD 25967	Clamp	2	
22	AD 25976/A	Stop Plate	1	
23	AD 25976/B	Stop Plate	1	
24	CD 25989	Foot	1	
25	AD 100259	Serial No. Label	1	
26				
27				
28				
29				
30				
31	24-6001	Drawstring Bag	1	
32	23-0006	Fuseline .1 amp	2	
33	23-0008	Fuseline .2 amp	4	
34				
35				
36	23-0003	Fuseline 0.25 amp	2	
37	26-3000	Lamp 12v .1 amp	2	
38	24-0009	Allen Key 3/16 A/F	1	
39	23-3019	Plug Co-Axial	2	

* To be issued later

Item No.	Part No.	Description	Qty.	Vendor *
40				
41				
42	10-2018	Power Lead Assy.	1	

* To be issued later

TABLE 8-2

PARTS LIST

CHASSIS ASSEMBLY 11-0001

Item No.	Part No.	Description	Qty.	Vendor *
1				
2	11-0033	Power Supply Assy 565/541	1	
3	11-0116	Attenuator Assy	1	
4				
5	10-2011	C/F Assy No. 1 SA 565/541	1	
6	10-2012	C/F Assy No. 2 SA 565/541	1	
7				
8				
9				
10	13-0000	Panel Front Mounting	1	
11	13-0001	Centre Member	1	
12	13-0002	Side Member R.H.	1	
13	13-0003	Side Member L.H.	1	
14	13-0004	Rear Panel	1	
15	13-0005	Rear Panel	1	
16				
17	13-0115	Tray	1	
18	13-0131	Blanking Plate	1	
19				
20	15-0017	Spacer Tappex	5	
21				
22	20-0822	Resistor Comp 1/10W 10% 8.2k	1	
23	20-0182	Resistor Comp 1/10W 10% 1.8k	1	
24	20-0100	Resistor Comp 1/10W 10% 10	1	
25	23-1005	Indicator	1	
26	23-4004	Switch Toggle	1	
27	23-4002	Switch slide	1	
28	23-4003	Switch Push Button	1	
29	23-5034	Edge Connector 12 way	1	
30	23-5007	Edge Connector 23 way	1	

* To be issued later

TABLE 8-3

PARTS LIST

ATTENUATOR ASSEMBLY 11-0116

Item No.	Part No.	Description	Qty.	Vendor *
1	17-0004	Rotary Switch	1	
2				
3				
4				
5	19-0061	Attenuator P.C. Board Assy.	1	
6				
7				
8	23-3003	BNC Socket Bulkhead (Jack)	1	

* To be issued later

TABLE 8-4

PARTS LIST

ATTENUATOR P.C.B. ASSEMBLY 19-0061

Item No.	Part No.	Description	Qty	Vendor *
1	18-0061	Board P.C.	1	
2				
3				
4				
5	20-3221	Resistor MO 1/2W ±10% 220	1	
6	20-3680	Resistor MO 1/2W ±10% 68	2	
7				
8				
9				
10	21-2583	Capacitor S/Mica Button 500v 10% 3Kp	1	

* To be issued later

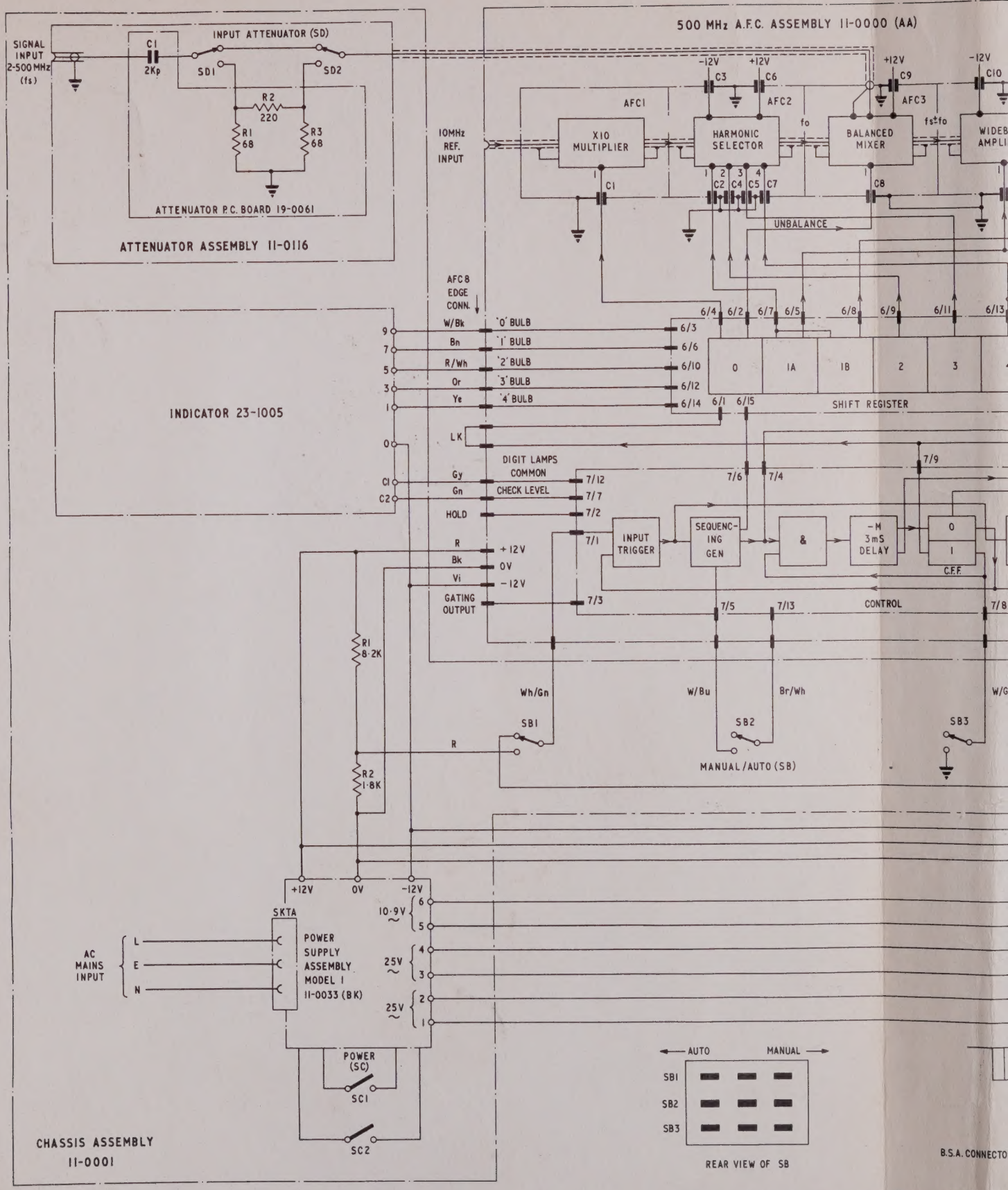
TABLE 8-5

COMPONENTS LIST

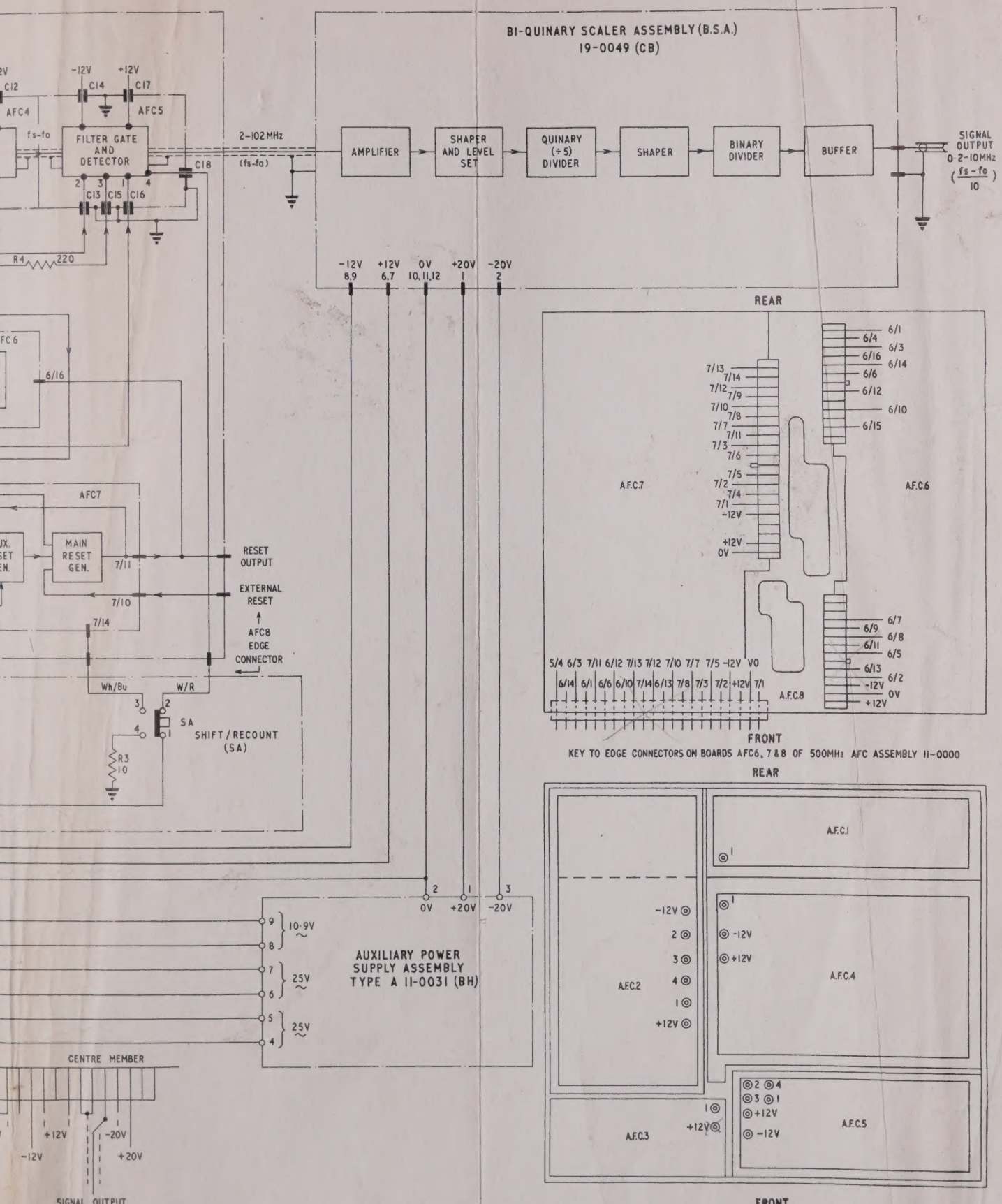
AUTOMATIC FREQUENCY CONVERTER SA.541

Cct. Ref.	Parts List Reference Item	Table	Physical * Location Grid	Fig.
Resistors				
R1	22	8-2		
R1	6	8-4		
R2	23	8-2		
R2	5	8-4		
R3	24	8-2		
R3	6	8-4		
Capacitors				
C1	10	8-4		
Switches				
SA	28	8-2		
SB	27	8-2		
SC	26	8-2		
SD	1	8-3		
Sockets				
SKTA	8	8-3		

* To be issued later



Automatic Frequency Converter S



541: Detailed Block Diagram

Fig. 8-3

MP MASTER
MA24139